

## PATENT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING  
OF A CHANGE(PCT Rule 92bis.1 and  
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

DUBUC, Jean, H.  
Goudreau Gage Dubuc & Martineau  
Walker  
The Stock Exchange Tower  
Suite 3400, 800 Place Victoria  
P.O. Box 242  
Montreal, Quebec H4Z 1E9  
CANADA

Date of mailing (day/month/year) 21 March 2000 (21.03.00)	<b>IMPORTANT NOTIFICATION</b>
Applicant's or agent's file reference CG/12331.20	
International application No. PCT/CA99/00666	International filing date (day/month/year) 21 July 1999 (21.07.99)

1. The following indications appeared on record concerning:		
<input checked="" type="checkbox"/> the applicant	<input type="checkbox"/> the inventor	<input type="checkbox"/> the agent <input type="checkbox"/> the common representative
Name and Address BIOS AGRICULTURE INC. 2111 Lakeshore Road Sainte-Anne-de-Bellevue, Quebec H9X 3V9 Canada	State of Nationality CA	State of Residence CA
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	
2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:		
<input type="checkbox"/> the person	<input type="checkbox"/> the name	<input checked="" type="checkbox"/> the address <input type="checkbox"/> the nationality <input type="checkbox"/> the residence
Name and Address BIOS AGRICULTURE INC. 21,111 Lakeshore Road Sainte-Anne-de-Bellevue, Quebec H9X 3V9 Canada	State of Nationality CA	State of Residence CA
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	
3. Further observations, if necessary: The addresses for the applicant/inventors SMITH, Donald, BO, Pan, PRITHIVIRAJ, Balakrishnan, and HABIB, Ahsan have also been changed accordingly.		
4. A copy of this notification has been sent to:		
<input checked="" type="checkbox"/> the receiving Office	<input type="checkbox"/> the designated Offices concerned	
<input type="checkbox"/> the International Searching Authority	<input checked="" type="checkbox"/> the elected Offices concerned	
<input checked="" type="checkbox"/> the International Preliminary Examining Authority	<input type="checkbox"/> other:	

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer H. Zhou
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents  
United States Patent and Trademark  
Office  
Box PCT  
Washington, D.C.20231  
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 21 March 2000 (21.03.00)	
International application No. PCT/CA99/00666	Applicant's or agent's file reference CG/12331.20
International filing date (day/month/year) 21 July 1999 (21.07.99)	Priority date (day/month/year) 21 July 1998 (21.07.98)
Applicant SMITH, Donald et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

21 February 2000 (21.02.00)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland  Facsimile No.: (41-22) 740.14.35	Authorized officer  H. Zhou  Telephone No.: (41-22) 338.83.38
---	---

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference CG/12331.20	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/CA 99/ 00666	International filing date (day/month/year) 21/07/1999	(Earliest) Priority Date (day/month/year) 21/07/1998
Applicant BIOS AGRICULTURE INC. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

**1. Basis of the report**

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established by this Authority to read as follows:

CPMPOSITION FOR ACCELERATING SEED GERMINATION AND PLANT GROWTH

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

☐ None of the figures.

The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line

IPEA/

PTO/PCT Rec'd 19 JAN 2001

**PCT**  
**DEMAND**

**CHAPTER II**

under Article 31 of the Patent Cooperation Treaty:  
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority use only

Identification of IPEA

Date of receipt of DEMAND

**Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION**

Applicant's or agent's file reference  
CG/12331.20

International application No.  
PCT/CA99/00666

International filing date (day/month/year)  
21 July 1999 ( 21-07-99 )

(Earliest) Priority date (day/month/year)  
21 July 1998 ( 21-07-98 )

Title of invention  
COMPOSITION FOR ACCELERATING PLANT SEED GERMINATION, SEEDLING EMERGENCE, PLANT GROWTH AND METHODS USING SAME

**Box No. II APPLICANT(S)**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

BIOS AGRICULTURE INC.  
21,111 Lakeshore Road  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

Telephone No.:  
(514) 398-7851

Facsimile No.:  
(514) 398-7616

Teleprinter No.:

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CA

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

MCGILL UNIVERSITY  
3655 Drummond  
Montreal, Quebec  
H3G 1Y6  
CANADA

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CA

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

SMITH, Donald  
21,111 Lakeshore Road  
P.O. Box 86  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CA

☒ Further applicants are indicated on a continuation sheet.

## Continuation of Box No. II APPLICANT(S)

*If none of the following sub-boxes is used, this sheet is not to be included in the demand.*

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

BO, Pan  
21,111 Lakeshore Road  
P.O. Box 86  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

State *(that is, country)* of nationality:  
CA

State *(that is, country)* of residence:  
CN

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

DENG, Yinghai  
3655 Drummond  
Montreal, Quebec  
H3G 1Y6  
CANADA

State *(that is, country)* of nationality:  
CA

State *(that is, country)* of residence:  
CN

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

MIGNER, Pierre  
21,048 Lakeshore Road  
Ste-Anne-de-Bellevue, Quebec  
H9X 1S2  
CANADA

State *(that is, country)* of nationality:  
CA

State *(that is, country)* of residence:  
CA

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

ZHANG, Feng  
7 Glenaladale Terrace  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

State *(that is, country)* of nationality:  
CA

State *(that is, country)* of residence:  
CA



Further applicants are indicated on another continuation sheet.

## Continuation of Box No. II APPLICANT(S)

*If none of the following sub-boxes is used, this sheet is not to be included in the demand.*

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

PRITHIVIRAJ, Balakrishnan  
21,111 Lakeshore Road  
P.O. Box 86  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

State *(that is, country)* of nationality:  
CA

State *(that is, country)* of residence:  
IN

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

HABIB, Ahsan  
21,111 Lakeshore Road  
P.O. Box 86  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

State *(that is, country)* of nationality:  
CA

State *(that is, country)* of residence:  
BD

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:



Further applicants are indicated on another continuation sheet.

**Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE**

The following person is ☒ agent ☐ common representative  
 and ☒ has been appointed earlier and represents the applicant(s) also for international preliminary examination.  
☐ is hereby appointed and any earlier appointment of (an) agent(s) /common representative is hereby revoked.  
☐ is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official  
The address must include postal code and name of country.)*

DUBUC, Jean H.; LECLERC, Alain M.; PRINCE, Gaétan; LUPIEN, Marc;  
 BRITT, Katherine  
 GOUDREAU GAGE DUBUC  
 The Stock Exchange Tower  
 800 Place Victoria, Suite 3400  
 P.O. Box 242  
 Montreal, Quebec, H4Z 1E9, CANADA

Telephone No.:  
(514) 397-7449

Facsimile No.:  
(514) 397-4382

Teleprinter No.:

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

**Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION****Statement concerning amendments:\***

1. The applicant wishes the international preliminary examination to start on the basis of:

☒ the international application as originally filed.

the description ☒ as originally filed  
☐ as amended under Article 34

the claims ☒ as originally filed  
☐ as amended under Article 19 (together with any accompanying statement)  
☐ as amended under Article 34

the drawings ☒ as originally filed  
☐ as amended under Article 34

2. ☐ The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. ☐ The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

\* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

**Language for the purposes of international preliminary examination: ENGLISH**

☒ which is the language in which the international application was filed.  
☐ which is the language of a translation furnished for the purposes of international search.  
☐ which is the language of publication of the international application.  
☐ which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

**Box No. V ELECTION OF STATES**

The applicant hereby elects all eligible States (that is, all States which have been designated and which are bound by Chapter II of the PCT)

excluding the following States which the applicant wishes not to elect:

**Box No. VI CHECK LIST**

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:

- |   |   |        |
|---|---|--------|
| 1. translation of international application                             | : | sheets |
| 2. amendments under Article 34  | : | sheets |
| 3. copy (or where required, translation) of amendments under Article 19 | : | sheets |
| 4. copy (or, where required, translation) of statement under Article 19 | : | sheets |
| 5. letter   | : | sheets |
| 6. other ( <i>specify</i> )   | : | sheets |

For International Preliminary Examining Authority use only

received not received

<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>

The demand is also accompanied by the item(s) marked below:

- |  |   |
|--|---|
| 1. <input checked="" type="checkbox"/> fee calculation sheet                             | 4. <input type="checkbox"/> statement explaining lack of signature                                  |
| 2. <input type="checkbox"/> separate signed power of attorney                            | 5. <input type="checkbox"/> nucleotide and or amino acid sequence listing in computer readable form |
| 3. <input type="checkbox"/> copy of general power of attorney; reference number, if any: | 6. <input type="checkbox"/> other ( <i>specify</i> ):   |

**Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE**

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

GOUDREAU GAGE DUBUC

By: 

GAÉTAN PRINCE

For International Preliminary Examining Authority use only

- |  |   |
|--|---|
| 1. Date of actual receipt of DEMAND:   |   |
| 2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):   |   |
| 3. <input type="checkbox"/> The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply.                        | <input type="checkbox"/> The applicant has been informed accordingly. |
| 4. <input type="checkbox"/> The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.                               |   |
| 5. <input type="checkbox"/> Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82. |   |

For International Bureau use only

Demand received from IPEA on:



**PATENT COOPERATION TREATY**  
**PTO/PCT Rec'd 19 JAN 2001**

**PCT**

**NOTICE INFORMING THE APPLICANT OF THE  
COMMUNICATION OF THE INTERNATIONAL  
APPLICATION TO THE DESIGNATED OFFICES**

(PCT Rule 47.1(c), first sentence)

From the INTERNATIONAL BUREAU

To:

DUBUC, Jean, H.  
Goudreau Gage Dubuc & Martineau  
Walker  
The Stock Exchange Tower  
Suite 3400, 800 Place Victoria  
P.O. Box 242  
Montreal, Quebec H4Z 1E9  
CANADA

Date of mailing (day/month/year) 03 February 2000 (03.02.00)		<b>IMPORTANT NOTICE</b>	
Applicant's or agent's file reference CG/12331.20			
International application No. PCT/CA99/00666	International filing date (day/month/year) 21 July 1999 (21.07.99)	Priority date (day/month/year) 21 July 1998 (21.07.98)	
Applicant BIOS AGRICULTURE INC. et al			

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:  
AU,CN,EP,IL,JP,KP,KR,US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:  
AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CU,CZ,DE,DK,EA,EE,ES,FI,GB,GD,GE,GH,GM,HR,  
HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,  
SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZA,ZW  
The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).
3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on  
03 February 2000 (03.02.00) under No. WO 00/04778

**REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)**

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

**REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))**

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer  J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38



## REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference  
(if desired) (12 characters maximum) CG/12331.20

**Box No. I TITLE OF INVENTION**

COMPOSITION FOR ACCELERATING PLANT SEED GERMINATION, SEEDING EMERGENCE, PLANT GROWTH AND METHODS USING SAME

**Box No. II APPLICANT**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

BIOS AGRICULTURE INC.  
2111 Lakeshore Road  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

☐ This person is also inventor.

Telephone No.  
(514) 398-7851

Facsimile No.  
(514) 398-7616

Teleprinter No.

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CA

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

**Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

MCGILL UNIVERSITY  
3655 Drummond  
Montreal, Quebec  
H3G 1Y6  
CANADA

This person is:

☒ applicant only

☐ applicant and inventor

☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CA

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

**Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE**

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:

☒ agent ☐ common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

DUBUC, Jean H.; LECLERC, Alain M; PRINCE, Ga  tan; LUPIEN, Marc  
GOUDREAU GAGE DUBUC & MARTINEAU WALKER  
The Stock Exchange Tower  
800 Place Victoria, Suite 3400  
P.O. Box 242  
Montr  al, Quebec, H4Z 1E9, CANADA

Telephone No.  
(514) 397-7604

Facsimile No.  
(514) 397-4382

Teleprinter No.

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

## Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTOR(S)

*If none of the following sub-boxes is used, this sheet is not to be included in the request.*

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

SMITH, Donald  
2111 Lakeshore Road  
P.O. Box 86  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CA

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

BO, Pan  
2111 Lakeshore Road  
P. O. Box 86  
Ste-Anne-de-Bellevue, Quebec  
H9X 3V9  
CANADA

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CN

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

DENG, Yinghai  
3655 Drummond  
Montreal, Quebec  
H3G 1Y6  
CANADA

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CN

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

MIGNER, Pierre  
21048 Lakeshore Road  
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Montreal, Quebec  
H9X 1S2

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CA

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on another continuation sheet.

**Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTOR(S)**

*If none of the following sub-boxes is used, this sheet is not to be included in the request.*

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

ZHANG, Feng  
7 Glenaladale Terrace  
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H9X 3V9  
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This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
CA

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

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This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
IN

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

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This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:  
CA

State (that is, country) of residence:  
BD

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

- ☐ applicant only  
☐ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

**Box N.V. DESIGNATING STATES**

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

**Regional Patent**

- ☒ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line) .....

**National Patent (if other kind of protection or treatment desired, specify on dotted line):**

- |   |  |
|---|--|
| <input checked="" type="checkbox"/> <b>AE</b> United Arab Emirates                  | <input checked="" type="checkbox"/> <b>LR</b> Liberia  |
| <input checked="" type="checkbox"/> <b>AL</b> Albania                               | <input checked="" type="checkbox"/> <b>LS</b> Lesotho  |
| <input checked="" type="checkbox"/> <b>AM</b> Armenia                               | <input checked="" type="checkbox"/> <b>LT</b> Lithuania  |
| <input checked="" type="checkbox"/> <b>AT</b> Austria                               | <input checked="" type="checkbox"/> <b>LU</b> Luxembourg   |
| <input checked="" type="checkbox"/> <b>AU</b> Australia                             | <input checked="" type="checkbox"/> <b>LV</b> Latvia   |
| <input checked="" type="checkbox"/> <b>AZ</b> Azerbaijan                            | <input checked="" type="checkbox"/> <b>MD</b> Republic of Moldova  |
| <input checked="" type="checkbox"/> <b>BA</b> Bosnia and Herzegovina                | <input checked="" type="checkbox"/> <b>MG</b> Madagascar   |
| <input checked="" type="checkbox"/> <b>BB</b> Barbados                              | <input checked="" type="checkbox"/> <b>MK</b> The former Yugoslav Republic of Macedonia                      |
| <input checked="" type="checkbox"/> <b>BG</b> Bulgaria                              |  |
| <input checked="" type="checkbox"/> <b>BR</b> Brazil                                | <input checked="" type="checkbox"/> <b>MN</b> Mongolia   |
| <input checked="" type="checkbox"/> <b>BY</b> Belarus                               | <input checked="" type="checkbox"/> <b>MW</b> Malawi   |
| <input checked="" type="checkbox"/> <b>CA</b> Canada                                | <input checked="" type="checkbox"/> <b>MX</b> Mexico   |
| <input checked="" type="checkbox"/> <b>CH and LI</b> Switzerland and Liechtenstein  | <input checked="" type="checkbox"/> <b>NO</b> Norway   |
| <input checked="" type="checkbox"/> <b>CN</b> China                                 | <input checked="" type="checkbox"/> <b>NZ</b> New Zealand  |
| <input checked="" type="checkbox"/> <b>CU</b> Cuba                                  | <input checked="" type="checkbox"/> <b>PL</b> Poland   |
| <input checked="" type="checkbox"/> <b>CZ</b> Czech Republic                        | <input checked="" type="checkbox"/> <b>PT</b> Portugal   |
| <input checked="" type="checkbox"/> <b>DE</b> Germany                               | <input checked="" type="checkbox"/> <b>RO</b> Romania  |
| <input checked="" type="checkbox"/> <b>DK</b> Denmark                               | <input checked="" type="checkbox"/> <b>RU</b> Russian Federation   |
| <input checked="" type="checkbox"/> <b>EE</b> Estonia                               | <input checked="" type="checkbox"/> <b>SD</b> Sudan  |
| <input checked="" type="checkbox"/> <b>ES</b> Spain                                 | <input checked="" type="checkbox"/> <b>SE</b> Sweden   |
| <input checked="" type="checkbox"/> <b>FI</b> Finland                               | <input checked="" type="checkbox"/> <b>SG</b> Singapore  |
| <input checked="" type="checkbox"/> <b>GB</b> United Kingdom                        | <input checked="" type="checkbox"/> <b>SI</b> Slovenia   |
| <input checked="" type="checkbox"/> <b>GD</b> Grenada                               | <input checked="" type="checkbox"/> <b>SK</b> Slovakia   |
| <input checked="" type="checkbox"/> <b>GE</b> Georgia                               | <input checked="" type="checkbox"/> <b>SL</b> Sierra Leone   |
| <input checked="" type="checkbox"/> <b>GH</b> Ghana                                 | <input checked="" type="checkbox"/> <b>TJ</b> Tajikistan   |
| <input checked="" type="checkbox"/> <b>GM</b> Gambia                                | <input checked="" type="checkbox"/> <b>TM</b> Turkmenistan   |
| <input checked="" type="checkbox"/> <b>HR</b> Croatia                               | <input checked="" type="checkbox"/> <b>TR</b> Turkey   |
| <input checked="" type="checkbox"/> <b>HU</b> Hungary                               | <input checked="" type="checkbox"/> <b>TT</b> Trinidad and Tobago  |
| <input checked="" type="checkbox"/> <b>ID</b> Indonesia                             | <input checked="" type="checkbox"/> <b>UA</b> Ukraine  |
| <input checked="" type="checkbox"/> <b>IL</b> Israel                                | <input checked="" type="checkbox"/> <b>UG</b> Uganda   |
| <input checked="" type="checkbox"/> <b>IN</b> India                                 | <input checked="" type="checkbox"/> <b>US</b> United States of America                                       |
| <input checked="" type="checkbox"/> <b>IS</b> Iceland                               |  |
| <input checked="" type="checkbox"/> <b>JP</b> Japan                                 | <input checked="" type="checkbox"/> <b>UZ</b> Uzbekistan   |
| <input checked="" type="checkbox"/> <b>KE</b> Kenya                                 | <input checked="" type="checkbox"/> <b>VN</b> Viet Nam   |
| <input checked="" type="checkbox"/> <b>KG</b> Kyrgyzstan                            | <input checked="" type="checkbox"/> <b>YU</b> Yugoslavia   |
| <input checked="" type="checkbox"/> <b>KP</b> Democratic People's Republic of Korea | <input checked="" type="checkbox"/> <b>ZA</b> South Africa   |
|   | <input checked="" type="checkbox"/> <b>ZW</b> Zimbabwe   |
| <input checked="" type="checkbox"/> <b>KR</b> Republic of Korea                     | Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet: |
| <input checked="" type="checkbox"/> <b>KZ</b> Kazakhstan                            | <input type="checkbox"/> .....   |
| <input checked="" type="checkbox"/> <b>LC</b> Saint Lucia                           | <input type="checkbox"/> .....   |
| <input checked="" type="checkbox"/> <b>LK</b> Sri Lanka                             |  |

**Precautionary Designation Statement:** In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that these additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)

<b>Box No. VI PRIORITY CLAIM</b>					<input type="checkbox"/> Further priority claims are indicated in the Supplemental Box.				
Filing date of earlier application (day/month/year)		Number of earlier application		Where earlier application is:					
				national application: country		regional application:* regional Office		international application: receiving Office	
item (1) 21 July 1998		2,243,669		CA					
item (2)									
item (3)									
<input checked="" type="checkbox"/> The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): <u>(1)</u> <small>* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(iii)). See Supplemental Box.</small>									
<b>Box No. VII INTERNATIONAL SEARCHING AUTHORITY</b>									
Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):					Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):				
ISA/					Date (day/month/year)		Number		Country (or regional Office)
<b>Box No. VIII CHECK LIST: LANGUAGE OF FILING</b>									
This international application contains the following number of sheets:				This international application is accompanied by the item(s) marked below:					
request : 5				1. <input checked="" type="checkbox"/> fee calculation sheet					
description (excluding sequence listing part) : 48				2. <input type="checkbox"/> separate signed power of attorney					
claims : 5				3. <input type="checkbox"/> copy of general power of attorney; reference number, if any:					
abstract : 1				4. <input type="checkbox"/> statement explaining lack of signature					
drawings : 1				5. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s):					
sequence listing part of description : _____				6. <input type="checkbox"/> translation of international application into (language):					
Total number of sheets : 60				7. <input type="checkbox"/> separate indications concerning deposited microorganism or other biological material					
				8. <input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form					
				9. <input type="checkbox"/> other (specify):					
Figure of the drawings which should accompany the abstract: 1				Language of filing of the international application: ENGLISH					
<b>Box No. IX SIGNATURE OF APPLICANT OR AGENT</b>									
Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).									
GOUDREAU GAGE DUBUC & MARTINEAU WALKER									
By: _____									
ALAIN M. LECLERC									

For receiving Office use only			
1. Date of actual receipt of the purported international application:		2. Drawings:  <input type="checkbox"/> received:  <input type="checkbox"/> not received:	
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:			
4. Date of timely receipt of the required corrections under PCT Article 11(2):			
5. International Searching Authority (if two or more are competent): ISA/		6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid	

For International Bureau use only	
Date of receipt of the record copy by the International Bureau:	

# PCT

## FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International application No.

Applicant's or agent's  
file reference

CG/12331.20

Date stamp of the receiving Office

Applicant

BIOS AGRICULTURE INC., et al

### CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE ..... 200.00 **T**

2. SEARCH FEE ..... 1,874.00 **S**

International search to be carried out by

(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

### 3. INTERNATIONAL FEE

#### Basic Fee

The international application contains 60 sheets.

first 30 sheets ..... 641.00 **b<sub>1</sub>**

30 x \$15.00 = 450.00 **b<sub>2</sub>**  
remaining sheets additional amount

Add amounts entered at **b<sub>1</sub>** and **b<sub>2</sub>** and enter total at **B** ..... 1,091.00 **B**

#### Designation Fees

The international application contains 79 designations.

10 x 148.00 = 1,480.00 **D**  
number of designation fees amount of designation fee

payable (maximum 11)

Add amounts entered at **B** and **D** and enter total at **I** ..... 2,571.00 **I**

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at **I** is 25% of the sum of the amounts entered at **B** and **D**)

4. FEE FOR PRIORITY DOCUMENT (if applicable) ..... **P**

### 5. TOTAL FEES PAYABLE

Add amounts entered at **T**, **S**, **I** and **P**, and enter total in the TOTAL box

4,645.00

TOTAL

☐ The designation fees are not paid at this time.

### MODE OF PAYMENT

☐ authorization to charge  
deposit account (see below)

☐ bank draft

☐ coupons

☐ cheque

☐ cash

☒ other (specify):

☐ postal money order

☐ revenue stamps

VISA

### DEPOSIT ACCOUNT AUTHORIZATION (this mode of payment may not be available at all receiving Offices)

The RO/ CA ☐ is hereby authorized to charge the total fees indicated above to my deposit account.

☒ is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

☒ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

600000102

21 July 1999

Deposit Account Number

Date (day/month/year)

Signature

# PATENT COOPERATION TREATY

From the:  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

DUBUC, J  
GOUDREAU GAGE DUBUC  
The Stock Exchange Tower  
800 Place Victoria, Suite 3400  
Montréal, Quebec. H4Z 1E9  
CANADA

## PCT

### WRITTEN OPINION

(PCT Rule 66)

Rec'd 19 JAN 2001

Date of mailing  
(day/month/year)

06.04.00

Applicant's or agent's file reference

CG/12331.20

**REPLY DUE**

**within 3 month(s)**

from the above date of mailing

International application No.

PCT/CA99/00666

International filing date (day/month/year)

21/07/1999

Priority date (day/month/year)

21/07/1998

International Patent Classification (IPC) or both national classification and IPC

A01N63/00

Applicant

BIOS AGRICULTURE INC. et al.

1. This written opinion is the **first** drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I ☒ Basis of the opinion
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain document cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

**When?** See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

**How?** By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

**Also:** For an additional opportunity to submit amendments, see Rule 66.4.  
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis.  
For an informal communication with the examiner, see Rule 66.6.

**If no reply is filed**, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: **21/11/2000**.

Name and mailing address of the international preliminary examining authority:



European Patent Office - P.B. 5818 Patentlaan 2  
NL-2280 HV Rijswijk - Pays Bas  
Tel. +31 70 340 - 2040 Tx: 31 651 epo nl  
Fax: +31 70 340 - 3016

Authorized officer / Examiner

Fort, M

Formalities officer (incl. extension of time limits)

Cardenas, C

Telephone No. +31 70 340 3370





## WRITTEN OPINION

International application No. PCT/CA99/00666

### I. Basis of the opinion

1. This opinion has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".*):

#### Description, pages:

1-45 as originally filed

#### Claims, No.:

1-32 as originally filed

#### Drawings, sheets:

1/1 as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:  
☐ the claims, Nos.:  
☐ the drawings, sheets:

3. This opinion has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

### V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims 1-20, 22-32 : no
Inventive step (IS)	Claims 1-32: no
Industrial applicability (IA)	Claims

2. Citations and explanations

s s parate sheet

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:

**see separate sheet**

**Re Item V**

**Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such a statement**

The documents (D) of the prior art are numbered according to their order of appearance in the search report. This numbering will be maintained throughout the ensuring procedure.

Before dealing with the discussion of novelty and inventive step, the attention of the applicant is drawn to the following:  
the indication of use (" for enhancing plant growth seed germination and/or seedling emergence and/or growth of ..." and " for breaking the dormancy and/or quiescence of ...") does not imply new technical characteristics of the claimed compositions which would differentiate them from the LCO (lipo-chitooligosaccharide)-containing compositions of the prior art (see Guidelines III 4-8).

*cell* It is known from D1 that LCO's secreted by rhizobia do not only trigger the early steps of nodule organogenesis in leguminous plants but also redirect plant growth in nonlegumes (e.g. Tobacco) by activating development pathways. D1 is therefore novelty-destroying for the subject-matter of claims 1-4, 6-11, 13-20, 22-28, 31-32.

D2 teaches the use of lipo-oligosaccharides obtainable from a rhizobia e.g.

Rhizobium meliloti or Rhizobium leguminosarum for accelerating the formation of nodules and/or inducing transcription of symbiotic genes in leguminous plants e.g. alfafa. The concentrations of LCO are identical to those used in the present application (see D2, p.20, lines 16-21). D2 is therefore novelty-destroying for the subject-matter of claims 1-20, 22-25.

D3 describes further NOD factors obtained from rhizobia which have a broad host spectrum (not limited to leguminous plants) and which can be used, for example, to stimulate symbiotic processes in leguminous plants. D3 is therefore novelty-destroying for the subject-matter of claims 1-4, 6-11, 13-20, 22-25.

It is known from both D4 and D5 that LCO's produced by rhizobia are causative agents of the formation of root nodules in leguminous plants. Thus the subject-matter of claims 1-4, 9-11, 16-20, 22, 26 and 31-32 lacks novelty over each of the documents D4-D5.

The potential of nodule inducing Bradyrhizobium japonicum as plant growth regulator on non-legumes has been described in D8. Thus the subject-matter of claims 1-5, 9-12, 16-20, 22, 26-28 and 30-32 lacks novelty over D8.

A method of treating the roots of leguminous plants (e.g. soybean) for inducing root hair curling and root nodulation by treating the roots of the plants with a NOD factor isolated from Bradyrhizobium japonicum has been described in D6. D6 is therefore novelty-destroying for the subject-matter of claims 1-20 and 22-25.

A plant growth medium for a non-leguminous plant comprising a bacterium

selected from Rhizobium, Azorhizobium and Bradyrhizobium has been described in both D7 and D9. Thus each of the documents D7 and D9 are novelty-destroying for the subject-matter of claims 26-31.

↳ a strain of LCOs.

As to document D10, it relates to the inoculation of legume seeds with a strain of rhizobia and is thus novelty-destroying for the subject-matter of claims 26 and 32.

→ 643

The remaining novel subject-matter (claim 21) cannot be considered as inventive for the following reasons:

As can be seen from the above, D1 does not only relate to the same problem as the problem underlying the present invention, i.e. the provision of plant growth regulators for legumes as well as non-legumes but teaches also the same solution, that is the use of lipo-chitooligosaccharides secreted by rhizobia.

Although compositions containing LCO's and gibberellic acid have not been described in the above cited prior art, the addition of gibberellic acid appears to be obvious in view of D11 which teaches the application of gibberellic acid to soybean seeds before inoculation with Bradyrhizobium japonicum.

### **Re Item VII**

#### **Certain defects in the international application**

Claims 28 and 29 should read " the method of claim ...".

The following clerical error has been noted in claim 3: "Solonaceae" should read "Solanaceae".

# PATENT COOPERATION TREATY

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

## PCT

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT  
(PCT Rule 71.1)

To:

DUBUC, J  
GOUDREAU GAGE DUBUC  
The Stock Exchange Tower  
800 Place Victoria, Suite 3400  
Montréal, Quebec. H4Z 1E9  
CANADA

RECEIVED 19 JAN 2001

Date of mailing  
(day/month/year) 06.10.2000

Applicant's or agent's file reference  
CG/12331.20

**IMPORTANT NOTIFICATION**

International application No.  
PCT/CA99/00666

International filing date (day/month/year)  
21/07/1999

Priority date (day/month/year)  
21/07/1998

Applicant  
BIOS AGRICULTURE INC. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

#### 4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

12 OCT. 2000

3400 TOUR DE LA BOURSE  
C.P. 242, PLACE VICTORIA  
MONTRÉAL, QUÉBEC H4Z 1E9

Name and mailing address of the IPEA/



European Patent Office - P.B. 5818 Patentlaan 2  
NL-2280 HV Rijswijk - Pays Bas  
Tel. +31 70 340 - 2040 Tx: 31 651 epo nl  
Fax: +31 70 340 - 3016

Authorized officer

Cardenas, C

Tel. +31 70 340-3370



# PATENT COOPERATION TREATY

## PCT

### INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference CG/12331.20	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/CA99/00666	International filing date (day/month/year) 21/07/1999	Priority date (day/month/year) 21/07/1998
International Patent Classification (IPC) or national classification and IPC A01N63/00		
Applicant BIOS AGRICULTURE INC. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 5 sheets, including this cover sheet.

- ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 1-5 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand  21/02/2000	Date of completion of this report  06.10.2000
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# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/CA99/00666

## I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

### Description, pages:

1-45 as originally filed

### Claims, No.:

1-34 as received on 08/09/2000 with letter of 06/09/2000

### Drawings, sheets:

1/1 as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:



**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/CA99/00666

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**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)	Yes:	Claims	1-21 and 33-34
	No:	Claims	22-32
Inventive step (IS)	Yes:	Claims	1-21 and 33-34
	No:	Claims	22-32
Industrial applicability (IA)	Yes:	Claims	1-34
	No:	Claims	

**2. Citations and explanations**

**see separate sheet**

**Re Item V****Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

Notwithstanding the allegations of fraud concerning D1 and the fact that the data concerning the growth-promoting effects were found not to be reproducible, the teaching of D1 is limited to the effects of LCOs on cells grown in an artificial in vitro assay. Therefore the objections as to lack of novelty and inventive step based on D1 are not maintained.

Claims 1-21 and 33-34 can be considered as both novel and inventive since the documents D2 -D11 teaches LCO-induced nodulation and nitrogen fixation but do not teach or even suggest that LCOs can have an enhancing activity on seed germination, plant seedling emergence, plant growth or breaking of dormancy.

Before discussing the "method claims" 22-32, the attention of the applicant is drawn to the following:

"for assessing novelty of "method claims", contrary to the case of "use claims", only the technical steps carried out, that is in the present case treatment in the vicinity of one of a seed, root or plant with a composition containing a LCO", are taken into consideration, but not the intended purpose.

Therefore the objection as to lack of novelty of claims 22-32 is maintained in view of the prior art discussed below:

D2 describes the application of LCOs for treating leguminous plants and is therefore novelty destroying for the subject-matter of claims 22-25.

It is known from both D4 and D5 that LCOs produced by rhizobia are causative agents

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/CA99/00666

of the formation of root nodules in leguminous plants. Thus the subject-matter of claims 26 and 31-32 lacks novelty in view of each of the documents D4-D5.

NOD factors obtained from rhizobia have also been used in D3 for treating both leguminous and non-leguminous plants such as *Parasponia andersonii* (see D3, p.2, l.34). Thus the subject-matter of claims 22-25 lacks novelty vis-à-vis D3.

A method of treating the roots of leguminous plants for reducing root hair curling and root nodulation by treating the roots of the plant with a NOD factor isolated from *Bradyrhizobium japonicum* has been described in D6. D6 is therefore novelty destroying for the subject-matter of claims 22-25.

A plant growth medium for a non-leguminous plant comprising a bacterium selected from *Rhizobium*, *Azorhizobium* and *Bradyrhizobium* has been described in both D7 and D9. Thus each of the documents D7 and D9 is novelty destroying for the subject-matter of claims 26-31.

REPLACED BY  
ART 34 AMDT

Rec'd on 19 Jan 01

**WHAT IS CLAIMED IS:**

1. An agricultural composition for enhancing plant crop seed germination and/or seedling emergence and/or growth of a plant crop comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier.

2. The composition of claim 1, wherein said plant crop is a non-legume.

3. The composition of claim 2, wherein said plant crop is selected from the group consisting of Poaceae, Cucurbitaceae, Malvaceae, Asteraceae, Chenopodiaceae, Solonaceae and Brassicaceae.

4. The composition of claim 3, wherein said plant crop is selected from the group consisting of corn, cotton, cucumber, cantaloupe, lettuce, beet, canola and potato.

5. The composition of one of claims 1 to 4, wherein said LCO is obtainable from a rhizobia selected from the group consisting of *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.

6. The composition of claim 5, wherein said LCO is present in said composition at a concentration of between about  $10^{-5}$  M to about  $10^{-14}$  M.

7. The composition of claim 5, wherein said LCO is present in said composition at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.

8. The composition of claim 5, wherein said LCO is present in said composition at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

5 9. The composition of one of claims 1 to 8, wherein said composition is effective in enhancing seed germination and/or seedling emergence and/or growth of a plant crop under field conditions.

10 10. The composition of claim 1, wherein said plant is a member of the Fabaceae family.

11. The composition of claim 10, wherein said plant is selected from the group consisting of soybean, bean, alfalfa and clover.

15 12. The composition of claim 10 or 11, wherein said LCO is obtainable from a rhizobia selected from the group consisting of *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.

20 13. The composition of claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-5}$  M to about  $10^{-14}$  M.

25 14. The composition of claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.

15. The composition of claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

16. The composition of one of claims 10 to 15, wherein said composition is effective in enhancing seed germination and/or seedling emergence and/or growth of a plant crop under field conditions.

5 17. A composition for breaking the dormancy and/or quiescence of a plant comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier.

10 18. The composition of claim 17, wherein said plant is a member of the family of Solonaceae.

19. The composition of claim 18, wherein said plant is a potato.

15 20. The composition of claim 19, wherein said growth-promoting activity of said composition enables an increase in yield.

20 21. The composition of claim 19, further comprising gibberellic acid.

25 22. A method for enhancing seed germination and/or seedling emergence and/or growth of a plant, comprising a treatment in the vicinity of one of a seed, root or plant with a composition comprising an agriculturally effective amount of a lipo chitooligosaccharide (LCO) in admixture with an agriculturally suitable carrier medium, wherein said effective amount enhances seed germination and/or seedling emergence and/or growth of said plant in comparison to an untreated plant.

23. The method of claim 22, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-5}$  M to about  $10^{-14}$  M.

5 24. The method of claim 23, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.

10 25. The method of claim 24, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

15 26. A method for enhancing seed germination and/or seedling emergence and/or growth of a plant crop comprising incubating a rhizobial strain which expresses a lipo chitooligosaccharide (LCO) in the vicinity of one of a seed and/or root of said plant such that said LCO enhances seed germination and/or seedling emergence and/or growth of said plant crop.

20 27. The method of claim 26, wherein said plant crop is a non-legume.

25 28. The composition of claim 27, wherein said plant crop is selected from the group consisting of Poaceae, Cucurbitaceae, Malvaceae, Asteraceae, Chenopodiaceae, Solonaceae and Brassicaceae.

29. The composition of claim 28, wherein said plant crop is selected from the group consisting of corn, cotton, cucumber, cantaloupe, lettuce, beet, canola and potato.

30. The method of one of claims 26 to 29, wherein said rhizobia is selected from *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.

5                    31. The method of one of claims 26 to 30, wherein said LCO enhances seed germination and/or seedling emergence and/or growth of said plant under field conditions.

10                   32. The method of claim 26, wherein said plant crop is a legume in the Fabaceae family and wherein said LCO enhances seed germination and/or seedling emergence and/or growth of said legume under field conditions.





WHAT IS CLAIMED IS:

(59)

1. Use of an agricultural composition for enhancing plant crop seed germination and/or seedling emergence and/or growth of a plant crop comprising a growth-promoting amount of at least one lipo  
5 chitooligosaccharide (LCO) together with an agriculturally suitable carrier.
2. The use according to claim 1, wherein said plant crop is a non-legume.
3. The use according to claim 2, wherein said plant crop is selected from the group consisting of Poaceae, Cucurbitaceae, Malvaceae,  
10 Asteraceae, Chenopodiaceae, Solanaceae and Brassicaceae.
4. The use according to claim 3, wherein said plant crop is selected from the group consisting of corn, cotton, cucumber, cantaloupe, lettuce, beet, canola and potato.
5. The use according to one of claims 1 to 4, wherein said  
15 LCO is obtainable from a rhizobia selected from the group consisting of *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.
6. The use according to claim 5, wherein said LCO is present in said composition at a concentration of between about  $10^{-5}$  M to  
20 about  $10^{-14}$  M.
7. The use according to claim 5, wherein said LCO is present in said composition at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.
8. The use according to claim 5, wherein said LCO is  
25 present in said composition at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

9. The use according to one of claims 1 to 8, wherein said composition is effective in enhancing seed germination and/or seedling emergence and/or growth of a plant crop grown under field conditions.

10. The use according to claim 1, wherein said plant is a member of the Fabaceae family.

11. The use according to claim 10, wherein said plant is selected from the group consisting of soybean, bean, alfalfa and clover.

12. The use according to claim 10 or 11, wherein said LCO is obtainable from a rhizobia selected from the group consisting of *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.

13. The use according to claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-5}$  M to about  $10^{-14}$  M.

14. The use according to claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.

15. The use according to claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

16. The use according to one of claims 10 to 15, wherein said composition is effective in enhancing seed germination and/or seedling emergence and/or growth of a plant crop grown under field conditions.

17. A use of a composition for breaking the dormancy and/or quiescence of a plant comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier.

18. The use according to claim 17, wherein said plant is a member of the family of Solonaceae.

19. The use according to claim 18, wherein said plant is a potato.

5           20. The use according to claim 19, wherein said growth-promoting activity of said composition enables an increase in yield.

21. The use according to claim 19, further comprising gibberellic acid.

10           22. A method for enhancing seed germination and/or seedling emergence and/or growth of a plant, comprising a treatment in the vicinity of one of a seed, root or plant with a composition comprising an agriculturally effective amount of a lipo chitooligosaccharide (LCO) in admixture with an agriculturally suitable carrier medium, wherein said effective amount enhances seed germination and/or seedling emergence  
15 and/or growth of said plant in comparison to an untreated plant.

23. The method of claim 22, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-5}$  M to about  $10^{-14}$  M.

20           24. The method of claim 23, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.

25           25. The method of claim 24, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

26. A method for enhancing seed germination and/or seedling emergence and/or growth of a plant crop comprising incubating a rhizobial strain which expresses a lipo chitooligosaccharide (LCO) in the

vicinity of one of a seed and/or root of said plant such that said LCO enhances seed germination and/or seedling emergence and/or growth of said plant crop.

27. The method of claim 26, wherein said plant crop is a  
5 non-legume.

28. The method of claim 27, wherein said plant crop is selected from the group consisting of Poaceae, Cucurbitaceae, Malvaceae, Asteraceae, Chenopodiaceae, Solanaceae and Brassicaceae.

29. The method of claim 28, wherein said plant crop is  
10 selected from the group consisting of corn, cotton, cucumber, cantaloupe, lettuce, beet, canola and potato.

30. The method of one of claims 26 to 29, wherein said rhizobia is selected from *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.

31. The method of one of claims 26 to 30, wherein said LCO  
15 enhances seed germination and/or seedling emergence and/or growth of said plant grown under field conditions.

32. The method of claim 26, wherein said plant crop is a legume in the Fabaceae family and wherein said LCO enhances seed  
20 germination and/or seedling emergence and/or growth of said legume grown under field conditions.

33. Use of an agricultural composition for enhancing a non-legume plant crop seed germination and/or seedling emergence and/or  
25 growth of a plant grown under field conditions, comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier.

34. Use of an agricultural composition for enhancing a leguminous plant crop seed germination and/or seedling emergence and/or growth of a plant grown under field conditions, comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier.
- 5



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/CA99/00666 <b>(22) International Filing Date:</b> 21 July 1999 (21.07.99) <b>(30) Priority Data:</b> 2,243,669 21 July 1998 (21.07.98) CA <b>(71) Applicants (for all designated States except US):</b> BIOS AGRICULTURE INC. [CA/CA]; 2111 Lakeshore Road, Sainte-Anne-de-Bellevue, Quebec H9X 3V9 (CA). MCGILL UNIVERSITY [CA/CA]; 3655 Drummond, Montreal, Quebec H3G 1Y6 (CA). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicant (for US only):</b> SMITH, Donald [CA/CA]; 2111 Lakeshore Road, P.O. Box 86, Sainte-Anne-de-Bellevue, Quebec H9X 3V9 (CA). BO, Pan [CA/CN]; 2111 Lakeshore Road, P.O. Box 86, Sainte-Anne-de-Bellevue, Quebec H9X 3V9 (CA). DENG, Yinghai [CA/CN]; 3655 Drummond, Montreal, Quebec H3G 1Y6 (CA). MIGNER, Pierre [CA/CA]; 21048 Lakeshore Road, Sainte-Anne-de-Bellevue, Montreal, Quebec H9X 1S2 (CA). ZHANG, Feng [CA/CA]; 7 Glenaladale Terrace, Sainte-Anne-de-Bellevue, Quebec H9X 3V9 (CA). PRITHIVIRAJ, Balakrishnan [CA/IN]; 2111 Lakeshore Road, P.O. Box 96, Sainte-Anne-de-Bellevue,		Quebec H9X 3V9 (CA). HABIB, Ahsan [CA/BD]; 2111 Lakeshore Road, P.O. Box 86, Sainte-Anne-de-Bellevue, Quebec H9X 3V9 (CA). <b>(74) Agents:</b> DUBUC, Jean, H. et al.; Goudreau Gage Dubuc & Martineau Walker, The Stock Exchange Tower, Suite 3400, 800 Place Victoria, P.O. Box 242, Montreal, Quebec H4Z 1E9 (CA). <b>(81) Designated States:</b> AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). <b>Published</b> With international search report.
<b>(54) Title:</b> COMPOSITION FOR ACCELERATING SEED GERMINATION AND PLANT GROWTH		
<b>(57) Abstract</b> <p>Lipo Chitooligosaccharide (LCO) [NodBj-V(C18:1,Mefuc)] isolated from <i>Bradyrhizobium japonicum</i> strain 532C was able to stimulate seed germination/seedling emergence, or in the case of potato, sprouting, of a number of crop plants representing eight distantly related plant families (Poaceae, Fabaceae, Brassicaceae, Cucurbitaceae, Malvaceae, Asteraceae, Chenopodiaceae and Solanaceae) of plants, at 25 and/or at 15°C. It also promoted sprouting potato minitubers. Other LCOs [NodRM-V(C16:2,5) and LCO from <i>R. leguminosarum</i>] were also shown to also display growth-promoting effects on the tested crop plants. The compositions comprising at least one LCO are shown to be effective in promoting growth under both laboratory and field conditions. The invention thus also relates to methods for promoting seed germination and/or seedling emergence and/or growth of plants comprising subjecting the seeds and/or plants to an effective amount of an agricultural composition comprising at least one LCO.</p>		

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**TITLE OF THE INVENTION**

COMPOSITION FOR ACCELERATING SEED GERMINATION AND PLANT GROWTH

5

**FIELD OF THE INVENTION**

The present invention relates to agriculture. More specifically, the invention relates to plant seed germination, seedling emergence, quiescence-breakage and plant growth. Even more specifically, the present invention relates to compositions which accelerate plant seed germination, seedling emergence and plant growth of numerous types of crops and to methods using same.

**BACKGROUND OF THE INVENTION**

15 Symbiotic microorganisms can promote the growth of legumes by way of biological fixation of nitrogen. More specifically, rhizobiaceae are gram-negative soil bacteria which fix nitrogen and are involved in symbiotic association with these legumes. This symbiotic association between the bacteria and the legume enables the latter to grow in soils having low assimilable nitrogen levels. In return, through photosynthesis, the legume provides the bacteria with the energy it requires to reduce the atmospheric nitrogen into ammonia. This ammonia can then be used by the legume and enters into the nitrogen metabolism. The legume, of the Fabaceae family, forms nodules in which the rhizobia proliferate. The Rhizobiaceae family is in a state of taxonomic flux. It has been reported to comprise four main genera: Rhizobium, Bradyrhizobium, Sinorhizobium and Azorhizobium (U.S. 5,549,718). The symbiotic relationship between nitrogen-fixing bacteria or rhizobia and plants of the Fabaceae family enables the growth of the latter in soils having low levels of available nitrogen, thus reducing the need for nitrogen fertilizers. Since nitrogen fertilizers can significantly increase the cost of crops, and are

30



associated with a number of polluting effects, biological means to stimulate this symbiotic relationship and/or to decrease the use of nitrogen fertilizers is of great importance.

Initial recognition between *B. japonicum* and soybean involves exchange of molecular signals (Stacey et al, 1995). Legume roots secrete phenolic compounds (Dakora & Philips, 1996; Peters & Verma, 1990), largely from the area of root hair emergence, which act as chemo-attractants to (brady)rhizobia (Nap & Bisseling, 1990), and activate the *nod* genes. Flavones, isoflavones, and flavanones have been identified as the inducing molecules for (brady)rhizobial chemotaxis and for expression of *nod* genes, e.g. genistein, daidzein and several related compounds in soybean (Peters & Verma, 1990). These plant-to-bacteria signal compounds cause expression of the bacterial *nod* (also *noi* and *noe*) genes very rapidly (only a few minutes after exposure) and at very low concentrations ( $10^{-7}$  to  $10^{-8}$  M) (Peters et al., 1986). Generally this is through an interaction with *nodD*, which activates the common *nod* genes, although the situation may be more complex, as is the case in *B. japonicum*, where *nodD*<sub>1</sub>, *nodD*<sub>2</sub> and *nodVW* are involved (Gillette & Elkan 1996; Stacey 1995). Nod genes have been identified in the rhizobia that form nitrogen fixing relationships with members of the Fabiaceae family (see 5,549,718 and references therein). Recently, the plant-to-bacteria signal molecules have been shown to promote soybean nodulation and nitrogen fixation under cool soil temperatures (CA 2,179,879) and increase the final soybean grain yield on average of 10% in the field and up to 40% under certain conditions.

Among the products of the *nod* genes induced by the plant phenolic signal molecules are various enzymes involved in the synthesis of a series of lipo chitooligosaccharides (LCOs) (Spaink, 1995; Stacey, 1995). These newly synthesized LCOs act as bacterium-to-plant signals, inducing expression of many of the early nodulin genes (Long, 1989). This results in root hair deformation (including curling), cortical cell division leading to initiation of nodule meristems, secretion of additional *nod* gene inducers, and initiation of

infection threads (Verma, 1992). These bacterium-to-plant signals exert a powerful influence over the plant genome and, when added in the absence of the bacteria, can induce the formation of root nodules (Truchet et al., 1991). Thus, the bacteria-to-plant signals can, without the bacteria, induce all the gene activity for nodule organogenesis (Denarie et al., 1996; Heidstra & Bisseling, 1996). Moreover, the above-mentioned activities induced by LCOs can be produced by concentrations as low as  $10^{-14}$  M (Stokkermans et al. 1995). The mutual exchange of signals between the bacteria and the plant are essential for the symbiotic interaction. Rhizobia mutants unable to synthesize LCOs will not form nodules. Analysis of the *B. japonicum* *nod* genes indicates that ability to induce soybean nodulation requires at least: 1) a basic tetrameric Nod factor requiring only *nodABC* genes or 2) a pentameric LCO (C18:1, C16:0 or C16: fatty acid and a methyl-fucose at the reducing end, sometimes acetylated) requiring *nodABCZ* genes (Stokkermans et al. 1995).

When added to the appropriate legume, LCOs can cause the induction of nodule meristems (Denarie et al., 1996), and therefore cell division activity. One previous publication has shown that LCOs can induce cell cycle activities in a carrot embryogenesis system at levels as low as  $10^{-14}$  M (De Jong et al. 1993).

A chemical structure of lipo chitooligosaccharides, also termed "symbiotic Nod signals" or "Nod factor", has been described in U.S. Patents 5,549,718 and 5,175,149. These Nod factors have the properties of a lectin ligand or lipo-oligosaccharide substances which can be purified from bacteria or synthesized or produced by genetic engineering.

The relationship between environmental variables, such as low root zone temperature (RZT) and pH, and the interplay of molecular signals has only recently become a subject of investigation. For example, some soybean genotypes have less synthesis abilities for isoflavones under cool soil temperature, whereas a higher isoflavone concentration is needed to turn on the *nod* genes of *B. japonicum* (Zhang and Smith 1995 and 1997). The plant-to-

bacteria signal molecules (i.e. isoflavones) have been shown, among other things, to overcome the negative effect of low temperature on the early events of symbiotic nitrogen fixation (Canadian application number 2,179,879).

While the effects of plant-to-bacteria signal molecules (i.e. isoflavones) on nodulation, nitrogen fixation, growth and protein yield of legumes, such as soybean, and on bacteria-to-plant signal molecules (LCOs) on nodulation and nitrogen fixation in legumes have been described under certain conditions, the effect of the bacteria-to-plant signal molecules on the growth of non-legumes is unknown. In fact, the role of such bacteria-to-plant signal molecules on non-legumes has never been assessed. In addition, the effect of LCOs on processes other than nodulation of legumes has yet to be studied.

There thus remains a need to assess the effect of LCOs on seed germination, seedling emergence and/or growth of plants in general and especially of non-legume plants.

The present invention seeks to meet these and other needs.

The present description refers to a number of documents, the contents of which are herein incorporated by reference in their entirety.

## **SUMMARY OF THE INVENTION**

The invention concerns a composition for enhancing seed germination, seedling emergence and growth of plants and especially of crop plants. More specifically, the present invention relates to a composition comprising an LCO which can increase seed germination and/or seedling emergence and/or growth of a legume, in addition to acting as a trigger to initiate legume symbiotic nitrogen fixation. More particularly, the invention relates to increased seed germination and/or seedling emergence and/or growth of soybean, pea and red clover.

Surprisingly, the compositions of the present invention act not only on legumes such as soybean but on plants in general as exemplified with

non-legume crops from different plant families Poaceae, Cucurbitaceae, Malvaceae, Asteraceae, Chenopodiaceae and Solonaceae. More specifically, the non-legume crops exemplified herein include corn, cotton, cantaloupe, cucumber, canola, lettuce, potato and beet. The present invention thus also  
5 refers to compositions for enhancing seed germination and/or seedling emergence and/or growth of non-legumes. More particularly, the invention relates to compositions comprising an LCO for enhancing seed germination, seedling emergence and growth of non-legumes. Non-limiting examples of such non-legumes include cotton, corn, canola, potato, cucumber, cantaloupe, lettuce  
10 and beet. Broadly, the present invention relates to compositions comprising an LCO for promoting growth of a crop. Non-limiting examples of crop plants include monocot, dicot, members of the grass family (containing the cereals), and legumes.

Thus, the present invention relates to agricultural  
15 compositions comprising at least one LCO (and methods of using same) for promoting seed germination, and/or early development of seedlings, and/or emergence of sprouts from tubers, and/or rapid development of new plants from higher plant perinating structures.

In a particular set of experiments in the field, a composition  
20 of the present invention comprising an LCO was shown to significantly enhance early plant growth.

The invention in addition relates to methods for enhancing  
seed germination and/or seedling emergence and/or growth of plants and/or for  
breaking the dormancy thereof comprising a treatment in the vicinity of a seed  
25 or seedling or plant with an effective amount of an agricultural composition comprising an LCO and an agriculturally suitable carrier for a sufficient time and under conditions which enable an increased germination of the seed and/or an increased emergence of the seedling and/or an increased growth of the plant and/or a triggering of the growth of a dormant plant.

The invention also relates to compositions and methods for breaking the dormancy of a plant and initiating the growth thereof. In a particular embodiment, the invention relates to the breaking of dormancy of potato.

5           The Applicant is the first to show that a composition comprising an LCO can have a significant effect on seed germination, and/or seedling emergence of legumes. Moreover, the Applicant is the first to show the surprising effect of signal molecules involved in bacteria-legume signalling on the growth of non-legume plants. In addition, the Applicant is the first to show  
10   that a composition comprising an LCO had an effect on non-legume seed germination and/or seedling emergence and/or plant growth of the non-legume. Also, the Applicant is the first to show that an LCO can not only act as a dormancy breaker but that it can also significantly increase the yield of a dormant plant following the dormancy breakage, when compared to known  
15   dormancy breakers.

          While the seed germination and/or seedling emergence and/or plant growth enhancing capabilities of the compositions of the instant invention are demonstrated with corn, cotton, canola, potato, cantaloupe, lettuce, beet, cucumber, soybean, pea and red clover, they are applicable to  
20   plants in general and more especially to crop plants. Indeed, the plants chosen for the experiments presented herein are crops from significantly divergent plants in eight distinct families: (1) corn, the only monocot tested herein, in the family of grasses (Poaceae), which also contains the cereals; (2) cucumber and cantaloupe, the latter being a plant used horticulturally, and being slow to  
25   germinate at low temperature [its base temperature is about 14°C] (Cucurbitaceae); (3) cotton, one of the most important fibre crops on the planet (Malvaceae); (4) lettuce (Asteraceae); (5) beet (Chenopodiaceae); (6) potato, a very important crop (Solonaceae, which also includes tobacco, peppers and tomato); and two families of legumes (7) canola, representing the mustard group  
30   (Brassicaceae) and (8) soybean (representative of oil seed crop), bean

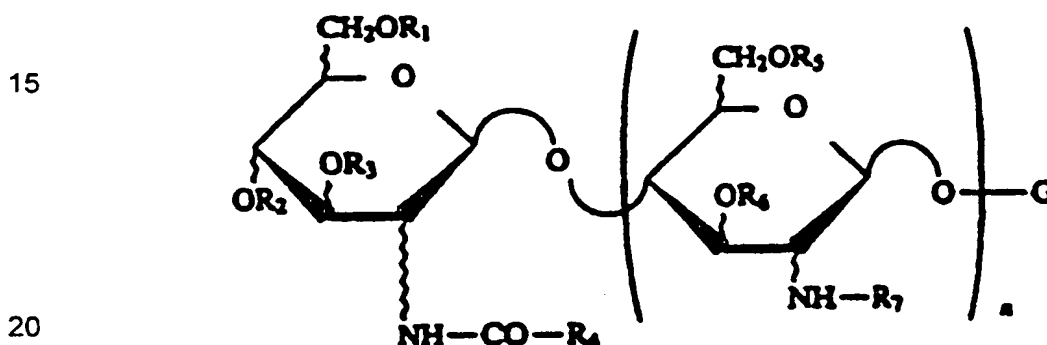
(representative of a crop for human consumption) and red clover and alfalfa (forage legumes) (all of the Fabaceae family).

In view of the diversity of the plants tested, and of the similar results obtained with these different crop plants, it can be predicted that such results will apply to crop plants in general. It follows that a person skilled in the art can adapt the teachings of the present invention to other crops. Non-limiting examples thereof include tobacco, tomato, wheat, barley, rice, sunflower and plants grown for flower production (daisy, carnation, pansy, gladiola, lilies and the like). It will be understood that the compositions can be adapted to specific crops, to meet particular needs.

In accordance with the present invention, there is thus provided an agricultural composition for enhancing plant crop seed germination and/or seedling emergence and/or growth of a plant crop comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier. There is also provided a composition for breaking the dormancy and/or quiescence of a plant, comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier. Furthermore, there is provided a method for enhancing seed germination and/or seedling emergence and/or growth of a plant, comprising a treatment in the vicinity of one of a seed, root or plant with a composition comprising an agriculturally effective amount of a lipo chitooligosaccharide (LCO) in admixture with an agriculturally suitable carrier medium, wherein the effective amount enhances seed germination and/or seedling emergence and/or growth of the plant in comparison to an untreated plant. There is further provided a method for enhancing seed germination and/or seedling emergence and/or growth of a plant crop comprising incubating a rhizobial strain which expresses a lipo chitooligosaccharide (LCO) in the vicinity of one of a seed and/or root of the plant such that the LCO enhances seed germination and/or seedling emergence and/or growth of the plant crop.

As used herein, the term "rhizobia" is used broadly to refer to bacterial strains which are involved in a nitrogen fixing symbiotic relationship with a legume.

As used herein, the term "LCO" refers broadly to a Nod factor which is under the control of at least one nodulation gene (*nod* gene), common to rhizobia. LCO therefore relates to a bacteria-to-plant signal molecule which induces the formation of nodules in legumes and enables the symbiotic bacteria to colonize same. Broadly, LCOs are lipo chitooligosaccharide signal molecules, acting as phytohormones, comprising an oligosaccharide moiety having a fatty acid condensed at one of its end. An example of an LCO is presented below as formula I



in which:

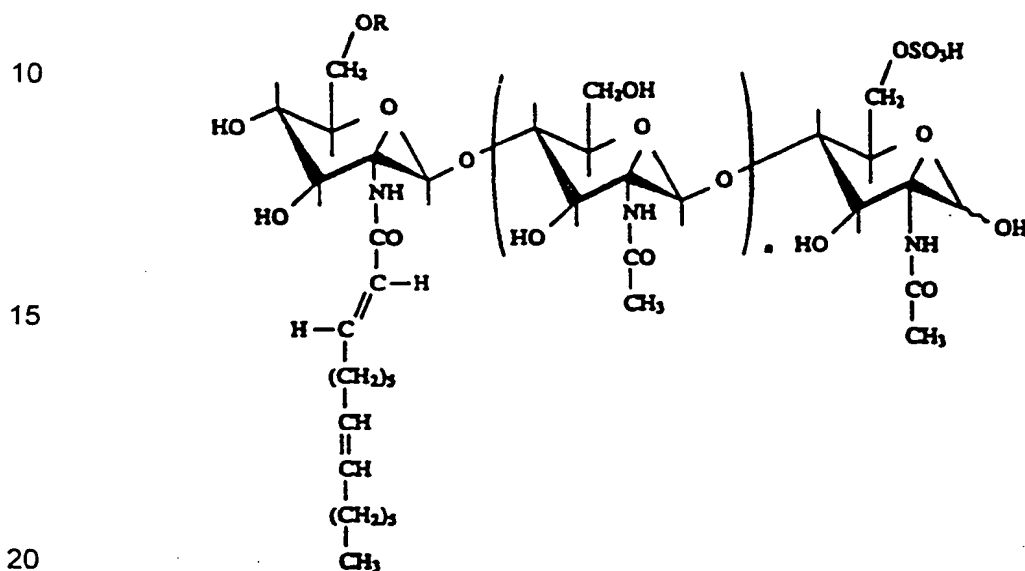
G is a hexosamine which can be substituted, for example, by an acetyl group on the nitrogen, a sulfate group, an acetyl group and/or an ether group on an oxygen,

$R_1$ ,  $R_2$ ,  $R_3$ ,  $R_5$ ,  $R_6$  and  $R_7$ , which may be identical or different, represent H,  $\text{CH}_3\text{CO}-$ ,  $\text{C}_x\text{H}_y\text{CO}-$  where  $x$  is an integer between 0 and 17, and  $y$  is an integer between 1 and 35, or any other acyl group such as for example a carbamyl,

$R_4$  represents a mono-, di- or triunsaturated aliphatic chain containing at least 12 carbon atoms, and

$n$  is an integer between 1 and 4.

More specific LCOs from *R. meliloti* have also been described  
 5 in 5,549,718 as having the formula II



in which  $R$  represents  $H$  or  $CH_3CO-$  and  $n$  is equal to 2 or 3.

25 Even more specific LCOs include NodRM, NodRM-1, NodRM-3. When acetylated (the  $R = CH_3CO-$ ), they become AcNodRM-1, and AcNodRM-3, respectively (U.S. 5,545,718).

LCOs from *B. japonicum* have also been characterized in U.S. 5,175,149 and 5,321,011. Broadly, they are pentasaccharide phytohormones comprising methylfucose. A number of these *B. japonicum*-derived LCOs are  
 30



described : BjNod-V ( $C_{18:1}$ ); BjNod-V ( $A_C$ ,  $C_{18:1}$ ), BjNod-V ( $C_{16:1}$ ); and BjNod-V ( $A_C$ ,  $C_{16:0}$ ), with "V" indicating the presence of five N-acetylglucosamines; "Ac" an acetylation; the number following the "C" indicating the number of carbons in the fatty acid side chain; and the number following the ":" the number of double bonds.

It shall also be understood that compositions comprising different LCOs, are encompassed within the scope of the present invention. Indeed, while the present invention is exemplified with NodBj-V( $C_{18:1\Delta}$ )11 also known as BjNod-V( $C_{18:1}$ MeFuc); NodRM-V( $C_{16:2}$ , S); and NodRI, any LCO produced by a rhizobia which is capable of entering into a nitrogen fixation relationship with a legume (i.e. a member of the Fabiaceae family) is expected to have the potential to show the same properties as those described herein. It will be clear to the person of ordinary skill that the selection of a rhizobia known to be expressing LCOs at high levels, or known to express an LCO having an effect on a broader spectrum of legumes could be advantageous.

It will also be clear that the LCO compositions of the present invention could also comprise more than one signal molecule. Non-limiting examples of such compositions include agricultural compositions comprising in addition to one LCO: (1) at least one additional LCO; (2) at least one plant-to-bacteria signal molecule; (3) gibberellic acid or other agents or compounds known to promote growth or fitness of plants; and mixtures of such compositions (1), (2) or (3).

It shall be clear that having identified new uses for LCO, bacteria could be genetically engineered to express *nod* genes and used for producing LCOs or for direct administration to the plants and/or seeds.

Thus, while the instant invention is demonstrated in particular with LCOs from *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *R. leguminosarum* and selected legumes and non-legume crops, the invention is not so limited. Other legume crops, non-legume crops and rhizobial strains may

be used using the same principles taught herein. Preferred matching of rhizobia with legume crop groups include, for example:

	<u>rhizobial species</u>	<u>Legume crop group</u>
	<i>R. meliloti</i>	alfalfa, sweet clover
5	<i>R. leguminosarum</i>	peas, lentils
	<i>R. phaesolii</i>	beans
	<i>Bradyrhizobium japonicum</i>	soybeans
	<i>R. trifolii</i>	red clover

As will be apparent to the person of ordinary skill to which the present invention is directed, the growth-stimulating compositions of the present invention can be applied to other crop plants and especially to other warm climate adapted crop plants (plants or crops having evolved under warm conditions [i.e. tropical, subtropical or warm temperature zones] and whose metabolism is optimized for such climates). It should be understood that the growth-enhancing compositions of the present invention should find utility whenever a particular crop is grown in a condition which limits its growth. More particularly, whenever a particular plant crop is grown at a temperature which is below its optimum temperature for seed germination, seedling emergence, growth and the like. Such temperatures are known in the art. For example, optimum temperatures for germination of corn, soybean, rice and cotton are 30°C, 34-36°C, 30-32°C, and 34°C, respectively. The minimum germination temperatures (or base temperatures) for these crops are 9°C, 4°C, 8 to 10°C, and 14°C, respectively, while the maximum germination temperatures are 40°C, 42-44°C, 44°C and 37°C, respectively. The compositions of the present invention therefore find utility, among other things, in enhancing germination of warm climate adapted crops when grown at temperatures between their base temperature for seed germination, and/or seedling emergence and/or growth and their optimum temperature for germination. The compositions of the present invention find utility in general in enhancing seed germination and/or seedling emergence and/or growth of crop plants when grown under conditions which

delay or inhibit seed germination and/or seedling emergence thereof. Non-limiting examples of such inhibiting conditions (as known from their signalling inhibition in bacteria-legume interactions, their inhibition or delay of the bacteria-plant symbiotic relationship) include pH stress, heat-stress, and water stress.

5 It will be nevertheless recognized that the compositions and methods of the present invention enhance growth of plants grown under optimal conditions.

Thus, the compositions and methods of the present invention should not be limited to plants growing under sub-optimal conditions.

10 The term "environmental conditions which inhibit or delay the bacterial-plant symbiotic relationship" should be interpreted herein as designating environmental conditions which postpone or inhibit the production and exchange of signal molecules between same and include, without being limited thereto: conditions that stress the plant, such as temperature stress,  
15 water stress, pH stress as well as inhibitory soil nitrogen concentrations or fixed nitrogen.

"An agriculturally effective amount of a composition" for increasing the growth of crop plants in accordance with the present invention refers to a quantity which is sufficient to result in a statistically significant  
20 enhancement of growth and/or of protein yield and/or of grain yield of the plant crop as compared to the growth, protein yield and grain yield of the control-treated plant crop. As will be seen below, the growth promoting activity of the LCOs are observable over a broad range of concentrations. Indeed, LCO growth-promoting activities can be observed at an applied concentration of  
25 about  $10^{-5}$  to  $10^{-14}$  M, preferably about  $10^{-6}$  to about  $10^{-12}$  M and more preferably about  $10^{-7}$  to about  $10^{-10}$  M.

The term "immediate vicinity of a seed or roots" refers to any location of a seed or roots wherein if any soluble material or composition is so placed, any exhibit of the plant or of the bacteria, or bacterial cells will be in

actual contact with the seed as it germinates or the roots as they grow and develop.

Direct or indirect methods of inoculation with the composition of the present invention can be employed. During direct inoculation the composition is applied directly to the seed prior to sowing. This can most simply be accomplished by spraying the seed with or dipping the seed into a liquid culture containing the desired components.

The recitation "short season condition" refers herein broadly to temperatures of the middle and temperate zones and shorter. Typically, the active growing season is around 1/2 to 2/3 of the year. Short season conditions broadly refers to a frost-free period of less than half the year, often on the order of 100 frost-free days.

By "nodulation gene-inducing" or "*nod* gene-inducing" is meant bacterial genes involved in nodule establishment and function.

By "seed germination" is meant a clear evidence of root growth developing from the embryo on the seed. When referring to an "increased seed germination", the Applicant refers to a significant difference in seed germination between the treated versus the control seed.

"Seedling emergence" is meant to refer to growth of the plant which is observable above the rooting medium surface. When referring to an "enhanced seedling emergence", the Applicant refers to a significant observable difference between the growth of the seedling in the treated versus the control.

#### **BRIEF DESCRIPTION OF THE DRAWING**

Having thus generally described the invention, reference will now be made to the accompanying drawing, showing by way of illustration a preferred embodiment thereof, and in which:

Figure 1 shows the seed germination enhancing effect of a composition according to the present invention on corn.

Other objects, advantages and features of the present invention will become more apparent upon reading of the following non-restrictive description of preferred embodiments with reference to the accompanying drawing which is exemplary and should not be interpreted as  
5 limiting the scope of the present invention.

#### **DESCRIPTION OF THE PREFERRED EMBODIMENT**

While the effects on nodulation were detected upon treatment of soybean with SoyaSignal® (a composition comprising both the plant-to-  
10 bacteria and bacteria-to-plant signal molecules), it was also noted that in many of the field experiments the plants that received some sort of genistein treatment emerged from the soil sooner. Thus, an experiment, in which genistein alone, *B. japonicum* alone, and genistein plus *B. japonicum* were added to soybean seeds under controlled environment conditions, was conducted. Because slow  
15 germination of corn (and other plants, as well) is a serious agricultural problem in eastern Canada because the weather conditions limit the growth thereof, corn was also treated in a similar fashion. The experiment showed that the seed germination and seedling emergence promoting effect was present with the combination of genistein plus *B. japonicum*, leading to the conclusion that the  
20 enhancing effects were due to the LCOs produced by genistein exposed *B. japonicum*. Purification (HPLC and otherwise) of the LCO most abundantly produced by genistein-stimulated *B. japonicum* (NodBj-V(C<sub>18:1Δ</sub> 11)) was carried out. This was aided by the gracious gift of enough LCO material to standardize the assay (G. Stacey, University of Tennessee at Knoxville; U.S. 5,175,149 and  
25 U.S. 5,321,011) which allowed both isolation and quantification. With isolated NodBj-V(C<sub>18:1Δ</sub> 11), research on the ability of this compound to stimulate seed germination, seedling emergence and growth of leguminous and non-leguminous plants could be conducted.

These experiments surprisingly demonstrated that the  
30 addition of SoyaSignal® (which comprises both an isoflavone and an LCO; the

latter at a concentration of about  $10^{-5}\text{M}$ ) accelerates the germination of corn seeds, whereas isoflavone solutions alone do not. Presumably this effect was due to the LCOs produced by *B. japonicum* cells and induced by the presence of isoflavones. When the seedlings were harvested (still at the mesocotyl stage) they were 44% longer and 33% as heavier in the genistein-*B. japonicum* treated versus non-treated plants (Figure 1). In addition, not only did seedling emergence increase, but the rate of cotton seed germination was also accelerated by the application of SoyaSignal®. The germination rate of cotton seeds treated with SoyaSignal® (0.66 ml/kg seed) increased by 145% compared to those control seeds that were treated with pure water. Both the corn and cotton experiments were conducted at low temperatures, 15°C and 17°C for corn seeds and for cotton seeds, respectively.

The field trial showed that the time of tasselling of sweet corn treated with SoyaSignal® (planted on May 6 on the Experimental Farm of McGill University, Quebec) was 1 to 2 days earlier compared to that of untreated plants. Soybean seeds that received SoyaSignal® (planted on June 22 in Martinsville, Illinois) emerged 8 hours earlier compared to control seeds while the first trifoliar fully expanded 1 day earlier. At the agronomy farm of Purdue University, Indiana, soybeans planted in early June and observed in early July were already one stage further in their development (V6) compared to the control plants (V5). In a farmer trial (in Jackson, Illinois), plants that received SoyaSignal® had many more nodules on the secondary roots and were 10% taller than untreated plants.

Thus, an LCO (a bacteria-to-plant signal molecule involved in the establishment of the symbiotic relationship between a rhizobia and a legume) can promote growth of corn, a monocot distantly related to legumes. Based on the evolutionary divergence of corn from legumes and the significant response thereof to the LCO treatments, corn was used as a model plant system in follow-up experiments. These experiments demonstrated that the results obtained with corn were also observable with all other crop plants tested.

Taken together, the laboratory data and field trials presented herein show that an LCO can increase seed germination, seedling emergence and plant growth of legumes and non-legume plants under controlled environment and field conditions.

5                   The signal molecules are also shown to break the dormancy of potato tubers. Of note, the dormancy experiments showed that the signal solution was better at increasing the yield of potato tubers as compared to other dormancy breakers (i.e. gibberellic acid).

10                   The precise mechanism of action of LCOs on seed germination, seedling emergence, dormancy and plant growth of legumes and non-legumes is not fully understood. The general understanding of the role of LCOs in signalling during the establishment of the legume-rhizobia symbiosis was described above. When added to the appropriate legume, LCOs can cause the induction of nodule meristems. Thus, it is possible that LCOs might be  
15                   normal signal molecules in higher plants, so that exogenously supplying them simply increases their levels and, therefore, the activity of the things they would normally regulate. Alternatively, there may be an endogenous class of signal molecules which play important roles in plant development, and have a conformation similar to those of LCOs. One possible candidate for this is the  
20                   oligosaccharins (Fry *et al.* 1993), some of which do stimulate meristem activity (Pavlova *et al.* 1992). LCOs are somewhat similar in structure and chemistry to the oligosaccharins (Fry *et al.* 1993) and can, in the broadest sense, be included in that group (Stokkermans *et al.* 1995). However, the signal molecules with a similar conformation need not be chemically similar, as demonstrated by the  
25                   ability of opiates (plant alkaloids) to fit into receptor sites normally occupied by endorphins (oligo-peptides). Nothing is known regarding the mechanisms by which LCOs cause this activity. Without being limited to a particular theory, the present invention is nevertheless the first to have identified a seed germination, and/or seedling emergence and/or dormancy breaking and/or plant growth  
30                   promoting effect of a composition comprising LCOs on non-legume plants.

Crops, such as soybean, corn and cotton evolved in relatively warm climates and, as a result, have high base temperatures for germination, being of about 5°C for soybean, 10°C for corn and 14°C for cotton. These high base germination temperatures lead to slow emergence after planting, resulting in slow leaf ground cover early in the season (when the temperature is sub-optimal), which in turn leads to poorer early season light interception, poorer competition with weeds (and therefore greater need for herbicide application) and increased soil erosion during heavy rainfall events. To simplify, these crops are often grown under conditions which limit their seed germination, and/or seedling emergence and/or growth. Hence, the use of a growth-promoting factor which is in limiting amount can compensate for a deficiency or stress in the growth conditions. Using SoyaSignal® as a plant growth regulator could thus partially overcome the negative effects of environmental stress conditions, such as low soil temperature on crop seed germination, seedling emergence and plant development. Thus, the present invention provides the means to improve the production of crops of tropical and subtropical origin in the temperate zones and may extend their production into shorter season areas. In addition, the present invention provides the means to improve production of crops growing under stress conditions.

The present invention is illustrated in further detail by the following non-limiting examples.

#### **EXAMPLE 1**

##### **Induction of LCO production by *Bradyrhizobium japonicum***

The first culture containing *Bradyrhizobium japonicum* (strain 532C) was grown at 28°C in 100 -125 mL of sterile yeast mannitol media (YEM) with pH 6.8, shaken at 150 rpm until the OD<sub>620</sub> reaches 0.4-0.6 (4-6 days). Thereafter, a 2L bacterial subculture was started by inoculating with material from the first culture (5 mL of first culture per 250 mL of YEM media), for 5-7 days (OD<sub>620</sub> - 0.8-1.0), as above. At this stage, 0.25 L of 50 µM genistein (in



methanol) were added to each 250 mL of bacterial subculture (genistein concentration of 5  $\mu$ M ) and the culture was incubated for 48-96 hours, the flavone thereby inducing LCO production in the bacterial cells.

5

### **EXAMPLE 2**

#### **Induction of LCO production by *Rhizobium meliloti* or *Rhizobium leguminosarum***

The first culture of *Rhizobium meliloti* strain RCR2011 was grown at 28°C in 100-125 mL of sterile yeast mannitol media (YEM) with pH 6.8, shaken at 150 rpm until the OD<sub>620</sub> reaches 0.4-0.6 (2-3 days). Thereafter, a 2L bacterial subculture was started by inoculating first culture (5 mL of first culture per 250 mL of YEM media), for 2-3 days (OD<sub>620</sub> - 0.8-1.0), as above. At this stage, 0.25 mL of 50  $\mu$ M luteolin (in methanol) was added to each 250 mL of bacterial subculture (luteolin concentration of 5  $\mu$ M ) and the culture was incubated for 48 hours, the flavone thereby inducing LCO production in the bacterial cells.

For LCO production by *Rhizobium leguminosarum*, the rhizobia was grown similarly as above. The flavone (naringenin) was added to the subculture of *R. leguminosarum* (10  $\mu$ M) and the procedure carried out as above.

20

### **EXAMPLE 3**

#### **Extraction and purification of LCOs**

Two liters of bacterial subculture were phase-partitioned against 0.8 L of HPLC-grade 1-butanol by shaking overnight. The upper butanol layer was then transferred to a 1 L evaporation flask and evaporated at 80°C to 2-3 mL of light brown, viscose material with a Yamato RE500 Rotary Evaporator, which was resuspended in 4 mL of 18% acetonitrile and kept in the dark at 4 °C in a sealed glass vial.

25

HPLC analysis was conducted with a Vydac C18 reversed-phase column with flow rate 1.0 mL/min and a Vydac guard column. As a baseline, acetonitrile (AcN/ H<sub>2</sub>O; w/w) was run through the system for at least 10 min. When the sample was loaded, an isocratic elution was started by 18% of AcN for 45 min. This step aims at removing all non-polar contaminant light fractions. Thereafter, a gradient elution for 90 min. with 18-82% AcN was performed. LCOs began to elute after 94-96 min. of HPLC run time.

For the purification of LCOs from *R. leguminosarum* (which nodulates numerous legumes), the HPLC peaks were identified and compared to those obtained with *B. japonicum* and *R. meliloti*. LCO peaks which were different from those of these two other rhizobia were identified collected. Thus, it is strongly suggested that the *R. leguminosarum* LCOs used herein are different from that of *B. japonicum* or *R. meliloti*.

#### **EXAMPLE 4**

##### **Effect of LCO on emergence of some plant species**

Plastic pots (7.5 cm dia) were filled with 15g of autoclaved vermiculite. Seeds of corn (*Zea mays* - Poaceae), bean (*Phaseolus vulgaris* - Fabaceae), canola (*Brassica napus* - Brassicaceae), cucumber (*Cucumis sativus* - Cucurbitaceae), cantaloupe (*Cucumis melo* - Cucurbitaceae), cotton (*Gossypium* sp.- Malvaceae), lettuce (*Lactuca sativa* - Asteraceae), beet (*Beta vulgaris* - Chenopodiaceae), and soybean (*Glycine max* - Fabaceae), were placed at 2.5 cm deep at the rate of 5 or 10 seeds per pot. Pots were irrigated with either 25 mL of LCO solution at different concentrations ( $10^{-6}$  –  $10^{-14}$ M) or aqueous acetonitrile or water, as controls. Acetonitrile was included as one of the controls since LCO was purified in this solvent (see Example 3), after 4 days the pots were irrigated with 10 mL of water once every two days. Each treatment had 4 replications in a randomized block design. Pots were placed on a green house bench maintained at  $25 \pm 2^{\circ}\text{C}$  with a day/night cycle 16/8h and relative humidity of 70%, or in a growth chamber set at  $15^{\circ}\text{C}$  with a 16:8 day/night cycle.

As defined above, seed germination has occurred when clear evidence of root growth developping from the embryo on the seed is observed.

As the time required for seedling emergence of the species used in the experiment varied considerably, observation on seedling emergence was recorded when the emergence was observed for at least 50% in most of the treatments. As defined above, seedling emergence has occurred when growth of the plant can be observed above the rooting medium surface. The percent emergence was calculated. The data were analyzed with Statistical Analysis System, version 6.12 (SAS institute Inc. Cary, NC, USA).

LCO treatment reduced the time required from sowing to emergence of a number of economically important plant species tested. Among the species tested, *Z. mays*, *L. sativa*, *B. vulgaris*, *P. vulgaris*, and *G. max* showed significant increases in emergence when treated with LCO at 25°C (Table 1), while, *C. sativus* and *B. napus* showed similar effects at 15°C (Table 2).

**TABLE 1**  
**Effect of lipo chitooligosaccharide on**  
**seedling emergence (%) at 25°C**

Treatment	Zea mays	Beta vulgaris	Glycine max	Gossy- pium sp.	Cucumis melo	Letuca sativa	Phaseolus vulgaris
Control	40 c <sup>ψ</sup>	33 a	40 e	55 b	80 a	5 d	44 abc
10 <sup>-6</sup> M	76 ab	NT	65 d	88 a	NT	45 a	67 abc
10 <sup>-7</sup> M	68 abc	66.6	80 bc	66 ab	100 b	35 ab	89 a
10 <sup>-8</sup> M	84 a	NT	90 ab	88 a	NT	10 dc	78 ab
10 <sup>-9</sup> M	88 a	66 b	100 a	88 a	100 b	20 bcd	67 abc
10 <sup>-10</sup> M	84 a	NT	70 cd	88 a	NT	25 abcd	44 abc
10 <sup>-11</sup> M	68 abc	86 b	50 e	NT	100 b	26 abcd	22 c
10 <sup>-12</sup> M	48 abc	NT	80 bc	NT	NT	30 abc	33 bc
10 <sup>-13</sup> M	40 c	80 b	70 cd	NT	100 b	5 d	33 bc
10 <sup>-14</sup> M	40 c	NT	70 cd	NT	NT	10 d	33 bc

<sup>ψ</sup> means with in the same column, followed by the same letter are not significantly different ( $p \leq 0.05$ ) by ANOVA protected LSD test.

NT- Not tested

**TABLE 2**

**Effect of lipo chitooligosaccharide  
on seedling emergence at 15°C**

Treatment	<i>Cucumis sativus</i>	<i>Brassica napus</i>
Control	60 c <sup>ψ</sup>	32.5 c
Lipo chitooligosaccharide		
10 <sup>-6</sup> M	65 abc	35 bc
10 <sup>-7</sup> M	85 ab	32 c
10 <sup>-8</sup> M	80 ab	35 bc
10 <sup>-9</sup> M	70 abc	52 ab
10 <sup>-10</sup> M	50 c	62 a
10 <sup>-11</sup> M	80 ab	47 bc
10 <sup>-12</sup> M	80 ab	45 bc
10 <sup>-13</sup> M	70 abc	37 bc
10 <sup>-14</sup> M	70 abc	30 c

<sup>ψ</sup> means with in the same column, followed by the same letter are not significantly different ( $p \leq 0.05$ ) by ANOVA protected LSD test.

In some plants, germination/emergence promoting effects of LCOs is seen at all temperatures suitable for growth, while in others, it is only observed under temperature-limiting conditions.

5

**EXAMPLE 5****Effects of LCO on early growth of corn**

The percent seedling emergence was recorded at 4 days after sowing (DAS). Plant height was recorded from 4 DAS to 15 DAS. Plants were harvested at 15 DAS and leaf area, root length and the number of roots per plant  
10 were recorded. The plants were then dissected and placed in paper covers and dried at 90°C for 24h and the dry weights of roots, shoots and the spent seeds recorded. The data were analyzed with the Statistical Analysis System version 6.12 (SAS institute Inc. Cary, NC, USA).

In LCO treatments, seedling emergence started 2-3 days after  
15 seeding while in the control it was 3-4 days. LCO treatments significantly increased leaf area, root length, number of roots, shoot dry weight and root dry weight, while the weight of spent seed recorded significant decreases as compared to the control (Table 3). The optimum effect was observed at an LCO concentration of  $10^{-8}M$ . The decrease in spent seed weight is attributed to the rapid translocation of stored  
20 reserve from the seed endosperm to the embryo. Of interest, a dramatic increase of  $\alpha$ -amylase activity was observed in the treated seeds.

**TABLE 3**

**Effect of lipo chitooligosaccharide on early  
growth (after seedling emergence) of *Zea mays***

Treatment	Leaf area (cm <sup>2</sup> )	Root length (mm)	No. of roots	Plant height at 15 DAS (mm)	Root dry wt./plant (mg)	Spent seed dry wt. (mg)	Shoot dry wt./plant (mg)
Water	5.81 f <sup>v</sup>	103.1 e	5.1 e	79.8d	53.2 de	163.6 a	28.8 e
Acetonitrile	7.63 ef	106.3 e	5.8 de	94.1cd	65.4 e	147.4 ab	30.1 de
LCO 10 <sup>-5</sup>	11.7 cd	137.0 cd	6.8 cd	102.9c	75.7 cd	123.5 bc	41.6 bcd
LCO 10 <sup>-6</sup>	18.2 a	150.8 bc	7.66 abc	130.4ab	85.1 bc	90.7 cd	51.4 b
LCO 10 <sup>-7</sup>	15.7 ab	153.9 b	8.0 ab	130.1ab	96.5 ab	99.5 cd	51.6 b
LCO 10 <sup>-8</sup>	19.3 a	187.0 a	8.4 a	142.6a	103.4 a	76.3 d	66.2 a
LCO 10 <sup>-9</sup>	17.0 ab	144.4 cbd	7.75 abc	134.7ab	83.3 bc	93.7 cd	46.8 bc
LCO 10 <sup>-10</sup>	13.9 bc	149.1 bc	7.95 ab	127.1b	89.5 abc	89.8 cd	51.4 b
LCO 10 <sup>-11</sup>	8.51 def	132.1 d	6.69 cd	103.3	74.6 cd	115.9 bc	38.0 cde
LCO 10 <sup>-12</sup>	8.0 def	137.9 cd	7.25 d	98.3c	84.6 bc	105.4 cd	40.6 bcde
LCO 10 <sup>-13</sup>	10.4 cde	130.9 d	6.7 cd	91.8cd	85.4 bc	109.6 cd	43.6 bc
LCO 10 <sup>-14</sup>	11.2 cde	136.8 cd	7.36 abc	99.9c	90.2 abc	102.9 cd	46.6 bc

<sup>v</sup> means with in the same column, followed by the same letter are not significantly different ( $p \leq 0.05$ ) by ANOVA protected LSD test.

Taken together, Examples 4 and 5 and Tables 1-3 show that LCOs can stimulate seedling emergence in all tested plants. In addition, a significant growth stimulation of corn was observed. Furthermore, the spent seed weight results suggested that LCOs also had an effect on seed germination for all tested plants. The growth-promoting effect of LCOs on corn, a plant quite distantly related to legumes (i.e. corn is a monocot), strongly suggests that plants in general should show the same growth-responses to LCO treatment.

#### **EXAMPLE 6**

##### **Dormancy breaking activity of LCO on potato mini tubers**

Signal solution is a bacterial fermentation tank product, comprising approximately  $10^{-6}$  M LCO from *B. japonicum*. More specifically, signal solution is the supernatant from a culture of *B. japonicum* in which genestein (a flavone) had been introduced to promote LCO expression. Following the subculture of *B. japonicum*, the bacteria was removed. While the stimulatory effect of Signal solution in the soybean-*Bradyrhizobium japonicum* complex has been described (Zhang and Smith, 1995; Zhang *et al.* 1996), the effects of these plant substances in other plant species and their associated rhizospheres' organisms have not been investigated.

Gibberellic acid (GA) and kinetin affect both the germination rate and the percent germination of crop seeds.

Some studies have indicated that plant growth regulators (PGRs), such as gibberellic acids (GAs), stimulate seed germination at low temperatures. Durrant and Mash (1991) reported that adding gibberellins (GA<sub>4/7</sub>) to sugar-beet seeds (*Beta vulgaris* L. Var. *altissima*) was beneficial to seed germination under cold, wet conditions.

Kepczynski and Bialecka reported that Methyl jasmonate (JA-Me) inhibited or retarded germination of *Amaranthus caudatus* seeds in darkness at 24°C. Ethephon, ACC (1-aminocyclopropane-1-carboxylic acid) and gibberellins



(GA<sub>3</sub> or GA<sub>4+7</sub>) partially or completely reversed this inhibition depending on the concentration of JA-Me applied.

Indeed, gibberellic acid, as well as bromoethane, are used commercially to break dormancy and to stimulate sprout formation.

5                Treatments were carried out on microtubers (200–400 mg) that had been cold-stored for 8 wk to determine their effect on breaking dormancy. Signal solution was used at full strength (100%) or diluted to 20% (as for soybean), 12%, or 6% of full strength. GA<sub>3</sub> (500 mg l<sup>-1</sup>), water soaking, and control treatments were performed for comparison purposes. Microtuber soaking treatments lasted 24  
10 h and then incubation occurred either in the light (40 μ mol m<sup>-2</sup>s<sup>-1</sup> cool-white fluorescent) or in the dark. Five microtubers were used in each treatment. Observations for sprouted microtubers were made at 1 and 2 wk.

                  One hundred % signal solution was as effective as GA<sub>3</sub> (500 mg l<sup>-1</sup>) when evaluated after 1 wk with respect to the number of sprouted microtubers.  
15 Table 4 shows the effect of signal solution (SS) on dormancy breaking of potato microtubers as compared to the known dormancy breaker gibberellic acid (GA<sub>3</sub>) (200–450 mg) that had been cold-stored at 5°C for 8 weeks and evaluated after treatment and incubation with or without light for 1 and 2 weeks, for number of sprouts and for number with multiple sprouts (>1) at 2 weeks. One hundred %  
20 signal solution induced multiple sprouts and dark incubation favoured sprouting as compared with the light regime after 1 wk of incubation. The exact cause of dark incubation favouring 100% signal solution is not understood. One hundred % signal solution was more effective than diluted signal solution when numbers of sprouted microtubers were counted after 1 wk. After 2 wk of incubation all treatments were  
25 equally effective in causing sprouting but the signal solution and GA<sub>3</sub> solutions were most promotive of multiple sprouting which did not occur in the water soaking treatment and only in the control treatment incubated in the dark.

**TABLE 4**

**Effects of signal solution (SS) on dormancy breaking  
of potato microtubers as compared to the known  
dormancy breaker gibberellic acid (GA<sub>3</sub>)**

Treatments	Number of sprouted microtubers		Number of multiple sprouted microtubers (2wk)	Mean number of sprouts ± SE
	1wk	2wk		
GA <sub>3</sub> 500 mg l <sup>-1</sup> + light	1/5	5/5	2/5	2.5 ± 0.5
GA <sub>3</sub> 500 mg l <sup>-1</sup> - light	5/5	5/5	4/5	2.5 ± 0.3
100 % SS + light	0/5	5/5	2/5	2.5 ± 0.5
100 % SS - light	5/5	5/5	3/5	2.3 ± 0.3
20 % SS + light	0/5	4/5	0	0
20 % SS - light	2/5	5/5	2/5	2.0 ± 0
12 % SS + light	0/5	4/5	1/4	2.0 ± 0
12 % SS- light	2/5	5/5	2/5	2.0 ± 0
6 % SS + light	0/5	4/5	2/4	2.0 ± 0
6 % SS - light	1/5	5/5	2/5	2.0 ± 0
Water + light	0/5	4/5	0	0
Water - light	2/5	5/5	0	0
Control + light	0/5	5/5	0	0
Control - light	1/5	5/5	1/5	2.0 ± 0

Tuber sprouting of potatoes is somewhat comparable to seed germination in the sense that the plant meristems are activated and the plant is beginning to grow, following quiescence. A signal molecule involved in bacteria-legume signalling was shown to be effective in breaking the dormancy of a plant (potato) that is distantly related to the legumes. LCOs therefore seem to have a broad effect on breaking the dormancy or quiescence of plants.

#### **EXAMPLE 7**

##### **Effects of combinations of GA<sub>3</sub> and 100% signal solution in breaking dormancy of potato tubers**

The data presented in Example 6 suggested that the 100% signal solution (and thus the LCO purified from *B. japonicum*) was effective in breaking microtuber dormancy. However, the microtubers used in the trial had been cold-stored for 8 wk. In this trial, the effects of signal solution were evaluated in combination with GA<sub>3</sub> on minitubers with only 3 wk of cold storage. It was also investigated whether the effect of 100% signal solution might be synergistic if used with GA<sub>3</sub> (500 mg l<sup>-1</sup>).

Minitubers (20-30 g) with 3 wk cold storage treatment were soaked for 24 h in 500 mg l<sup>-1</sup> GA<sub>3</sub>, 100% signal solution, or a mixture of the two. Another treatment involved successive soaking for 12 h each, in first GA<sub>3</sub>, and then signal solution. A control treatment without soaking was also performed. Eight minitubers were used per treatment which were applied at room temperature (20°C). Microtubers were observed after 2 wk and the number of sprouted minitubers and the number with multiple sprouts were counted.

All treatments were able to break minituber dormancy except the control (Table 5). The 500 mg l<sup>-1</sup> GA<sub>3</sub> treatment alone or together with 100% signal solution, for 24 h, caused 100% sprouting, and significantly more multiple sprout formation than the other treatments. The 100% signal solution alone or in combination with 500 mg l<sup>-1</sup> GA<sub>3</sub> were as effective as 500 mg l<sup>-1</sup> GA<sub>3</sub> alone for breaking dormancy within 2 wk. However, less multiple sprouting occurred with 100% signal solution alone, or following 12 h GA<sub>3</sub> treatment, compared with the

GA<sub>3</sub> treatment alone or the combined GA<sub>3</sub> and Signal treatments. When working under the conditions tested, there were no clear synergistic effects of 100% signal solution in combinations with 500 mg l<sup>-1</sup> GA<sub>3</sub> on the number of sprouted tubers or multiple sprouts.

5

**TABLE 5**

**Individual and combined effects of GA<sub>3</sub> and 100% signal solution (SS) on dormancy breaking of minitubers that had been cold-stored for 3 weeks**

Treatments	Number of sprouted minituber	Number of minituber with multiple sprouts	Mean number of sprouts ± SE
GA <sub>3</sub> 500 mg l <sup>-1</sup> 24 h	8/8	6/8	3.37 ± 0.62
100% SS 24 h	7/8	2/7	1.33 ± 0.42
GA <sub>3</sub> 500 mg l <sup>-1</sup> + 100% SS 12 h + 12 h	8/8	6/8	2.37 ± 0.41
GA <sub>3</sub> 500 mg l <sup>-1</sup> + 100% SS Combination 24 h	8/8	6/8	3.75 ± 0.67
Control	0/8	0/8	0/8

These results suggest that bacteria-legume signal molecules are effective in breaking the dormancy of potatoes. Taken together with the results presented above (i.e. Example 4 and Table 1) showing the effects of a pure LCO in breaking the quiescence of seeds and promoting growth of a variety of distantly

5

related plants, strongly supports the contention that LCOs are effective at breaking the dormancy of potatoes and promoting the activity of plant meristems in general.

#### **EXAMPLE 8**

##### **5 Effectiveness of GA<sub>3</sub> and signal solution, as compared to bromoethane and mechanical injuries, in breaking dormancy**

Bromoethane (BE) was reported to break potato tuber dormancy when applied as a fumigant and it was found that BE at a concentration of 0.2 ml  
10 l<sup>-1</sup> was the most effective (Coleman, 1983). Conventionally, large potato tubers are cut into small pieces, each containing an eye, to be used as seed pieces. To obtain quick and uniform sprout emergence, potato tubers should be cut at least 2 wk before planting (Slomnicki and Rylski, 1964). Mechanical injury is also shown to contribute to sprout induction. The objective of this experiment was to compare the  
15 effects of known dormancy-breaking treatments on microtubers and minitubers 1) BE; 2) GA<sub>3</sub>; and 3) mechanical injury; with the newly identified dormancy breaker: LCOs.

Microtubers (200-500 mg) cold-stored for 8 wk and minitubers (20-35 g) cold-stored for 0, 2, or 8 wk were used for these experiments. BE (0.2 ml  
20 l<sup>-1</sup>) and mechanical injury (cutting in half, microwaving at full power for 10 sec) were compared with GA<sub>3</sub> (500 mg l<sup>-1</sup>), 100% signal solution, water soaking, and control treatments. Six microtubers or minitubers were used per treatment. Observations were made at 1, 2, 3, and 4 wk intervals and the number of sprouted tubers were counted. The evaluation period was extended because tubers with little  
25 or no cold storage treatment took longer to sprout.

GA<sub>3</sub> was the only agent which was able to break dormancy of minitubers that had not been cold-stored; 0/6 at 2 wk but 4/6 by 4 wk (minituber, 0 wk storage; Table 6). Minitubers with 2 wk cold storage that were treated with GA<sub>3</sub> also broke-dormancy; 0/6 at 2 wk but 5/6 by 4 wk with 2/6 showing multiple shoots.  
30 Signal solution treatment of minitubers cold-stored for 2 wk caused 1/6 (with multiple shoots) minitubers to break dormancy after 4 wk. For minitubers cold-stored for 8 wk, all treatments (including water soaking and control), except the

microwaving, showed some sprouting the first week and multiple sprouting was evident in the GA<sub>3</sub> (6/6), 100% signal solution (4/6), and BE (1/6) treatments by 2 wk. Cutting caused sprouting in 9/12 cut halves by 2 wk but only a few multiple shoots (2/12) were evident by 3 wk.

TABLE 6

Sprouting and (multiple sprouting) performance on minitubers and microtubers cold-stored for 0, 2, 4, or 8 weeks after exposure to Bromoethane (0.2 ml l<sup>-1</sup>), mechanical injury (cutting in half or microwaving), GA<sub>3</sub> (500 mg l<sup>-1</sup>), 100% signal solution, water soaking, and control treatments.

Treatments	Minituber (CS8W)				Minituber (CS2W)				Minituber (NCS)				Microtuber (CS8W)			
	1wk	2wk	3wk	4wk	1wk	2wk	3wk	4wk	1wk	2wk	3wk	4wk	1wk	2wk	3wk	4wk
GA <sub>3</sub> 500mg l <sup>-1</sup>	5/6	6/6 (6)	6/6 (6)	6/6 (6)	0	0	3/6	5/6 (2)	0	0	3/6	4/6	4/6	5/6 (3)	6/6 (3)	6/6 (6)
100% Signal solution	4/6	6/6 (4)	6/6 (4)	6/6 (4)	0	0	0	1/6 (1)	0	0	0	0	1/6	2/6	4/6	6/6 (1)
Bromoethane 0.2 ml l <sup>-1</sup>	3/6	4/6 (1)	6/6 (4)	6/6 (4)	0	0	0	2/6	0	0	0	0	2/6	4/6	4/6	6/6
Cutting into halves	7/12	9/12	12/12 (2)	12/12 (2)	0	0	0	1/12	0	0	0	0	5/12	8/12	9/12	10/12
Microwaving	0	0	1/6	2/6	0	0	0	0	0	0	0	0	0	0	0	1/6
Water	4/6	5/6	6/6 (1)	6/6 (1)	0	0	0	0	0	0	0	0	2/6	4/6	6/6	6/6
Control	2/6	4/6	6/6	6/6	0	0	0	0	0	0	0	0	3/6	4/6	6/6	6/6

'CS' stands for cold storage; 'W' for week; N for no  
'(') denotes number of tubers with multiple sprouts

With microtubers cold-stored for 8 wk, dormancy-breaking occurred within the first week in all treatments except microwaving. After 2 wk, sprouting had progressed in all treatments; water (4/6) was similar to GA<sub>3</sub> solution (5/6), BE (4/6), signal solution (4/6), and cutting (8/12). Only GA<sub>3</sub> solution (3/6 at 2 wk, 6/6 at 4 wk) and signal solution (1/6 at 4 wk) caused multiple sprout formation.

Signal solution (100%) was effective in causing sprouting in minitubers with 2 or 8 wk cold storage and microtubers with 8 wk cold storage but it was ineffective on minitubers that had not been cold-stored. GA<sub>3</sub> and 100 % signal solution induced multiple sprouts from different eye-points unlike the control BE, or cutting treatments, that induced single sprouts only from the rose end. BE worked well in inducing single sprouts in minitubers and microtubers with 8 wk cold-storage but was not as effective as GA<sub>3</sub> for minitubers that had not been cold-stored.

Cutting minitubers or microtubers in half after 8 wk cold storage induced single sprouts on each cut half. This occurred quite efficiently in minitubers (9/12 in 2 wk, 12/12 in 4 wk) and somewhat less efficiently with microtubers (8/12 in 2 wk, 10/12 in 4 wk). Cutting was not effective in breaking dormancy in minituber without cold storage and worked poorly in minitubers that had been cold stored for only 2 wk (0/12 after 2 wk, 1/12 after 4wk). Sprouting from two halves was good, in the sense that by cutting minitubers or microtubers in half, two propagules, each with one sprout were derived although a very insignificant number of minituber halves (2/12) showed multiple sprouting. However, cutting was risky in that this sometimes provided opportunities for fungal or bacterial infection. Microwaving induced limited sprouting but only in minitubers or microtubers that had been cold-stored for 8 wk, and not in the minitubers with 0 or 2 wk cold storage. Microwaving caused some tuber damage that may account for the reduced sprouting observed.

In short, signal solution was effective in promoting both sprouting and multiple sprouting of mini- and micro-tubers and, of the tested treatments, only GA<sub>3</sub> was better.



**EXAMPLE 9****Effectiveness of anti-ABA compared with other dormancy breaking treatments**

Anti-Abscisic acid (anti-ABA), the acetylenic analog of ABA, has never been used to induce sprouting in dormant potato tubers since it was first shown to be an ABA antagonist (Wilén *et al.*, 1993). However, anti-ABA has been used to terminate dormancy in canola seeds (PBI Bulletin, 1995). The objective of this experiment was to test anti-ABA for breaking dormancy in potato minitubers and compare its efficacy with other dormancy-breaking treatments.

Microtubers (200-600 mg) were cold-stored for 3 wk prior to the experiment. Seven microtubers were used per treatment. Treatments included 24 h soaks in anti-ABA or GA<sub>3</sub> (500 and 250 mg l<sup>-1</sup>, respectively) applied alone or in combination, GA<sub>3</sub> (500 mg l<sup>-1</sup> in combination with 100% signal solution, and water. Bromoethane (0.2 ml l<sup>-1</sup>) and control treatments were also performed. Observations were made after 2 wk in the dark at room temperature (20°C). Data included number of sprouted microtubers and number of multiple sprouts. Means of sprout number were calculated only from microtubers that had sprouted

Anti-ABA alone and in successive treatments or in combination with GA<sub>3</sub> was effective in breaking microtuber dormancy (Table 7). Among the different treatments using anti-ABA and GA<sub>3</sub> the greatest mean number of sprouts ( $1.8 \pm 0.48$ ) occurred when microtubers were soaked in a mixed solution of 500 mg l<sup>-1</sup> GA<sub>3</sub> and 500 mg l<sup>-1</sup> anti-ABA for 24 h but it was not significantly different from the 500 mg l<sup>-1</sup> GA<sub>3</sub> treatment ( $1.71 \pm 0.28$ ). The combined signal solution and GA<sub>3</sub> was not more effective than GA<sub>3</sub> alone and was less effective than any GA<sub>3</sub> and anti-ABA treatment in breaking dormancy.

**TABLE 7**

**Sprouting performance on microtubers cold-stored  
for 3 weeks and evaluated at 2 weeks after  
exposure to dormancy-breaking agents.**

Treatments	No. sprouted microtubers	Mean No. sprouts $\pm$ SE
GA <sub>3</sub> 500 mg l <sup>-1</sup> 24 h	7/7	1.71 $\pm$ 0.28
GA <sub>3</sub> 500 mg l <sup>-1</sup> + 100% SS 24 h	3/7	1.33 $\pm$ 0.29
Anti-ABA 500 mg l <sup>-1</sup> 24 h	5/7	1.4 $\pm$ 0.24
Anti-ABA 250 mg l <sup>-1</sup> 24 h	5/7	1.2 $\pm$ 0.20
GA <sub>3</sub> 500 mg l <sup>-1</sup> 12 h + Anti-ABA 500 mg l <sup>-1</sup> 12 h	6/7	1.33 $\pm$ 0.21
GA <sub>3</sub> 250 mg l <sup>-1</sup> 12 h + Anti-ABA 250 mg l <sup>-1</sup> 12 h	7/7	1.57 $\pm$ 0.29
GA <sub>3</sub> 500 mg l <sup>-1</sup> + Anti-ABA 500 mg l <sup>-1</sup> Combination 24 h	5/7	1.8 $\pm$ 0.48
GA <sub>3</sub> 250 mg l <sup>-1</sup> + Anti-ABA 250 mg l <sup>-1</sup> Combination 24 h	5/7	1.6 $\pm$ 0.24
Bromoethane	1/7	1.0 $\pm$ 0
Water	1/7	1.0 $\pm$ 0
Control (no treatment)	0/7	0

The overall results with anti-ABA underline its importance as a potential dormancy-releasing agent, as much so as  $GA_3$ . Anti-ABA and  $GA_3$  both induced multiple sprouts but sprouts were longer after  $GA_3$  than anti-ABA treatment. Both agents caused sprouts to emerge at various eyes over the tuber surface. However, the  $GA_3$ -induced multiple sprouts were profusely branched; a group of sprouts protruded from each eye, while the anti-ABA-induced sprouts were singles. The mechanism of dormancy breaking by anti-ABA and  $GA_3$  therefore was similar, but  $GA_3$  appeared stronger. These agents should be tested on an equimolar basis in the future.

#### **EXAMPLE 10**

##### **Harvests from minitubers sprouted using a range of dormancy-breaking treatments**

There is only limited information on the relative yield performance of potato tubers that were treated with dormancy-breaking agents (Choudhury and Ghose, 1960; Slomnicki and Rylski, 1964). Yields from potato tubers that were treated with  $GA_3$  at 25-100 mg l<sup>-1</sup> (Choudhuri and Ghose, 1960) or 5-40 mg l<sup>-1</sup> (Slomnicki and Rylski, 1964) were reduced compared with untreated controls. The objective of this experiment was to evaluate the effect of dormancy-breaking agents on subsequent yield in greenhouse pot trials.

Minitubers (20-35 g) that were cold-stored for 8 wk were given dormancy-releasing treatments including 24 h soaking in  $GA_3$  (500 mg l<sup>-1</sup>), 100% signal solution, or water. Other treatments included BE (0.2m l<sup>-1</sup>), cutting in half, and the control. All minitubers were observed at 3 wk following treatment and the number of sprouts were noted at the time of planting. Five minitubers per treatment were individually planted into 11 x 12 cm plastic pots in the greenhouse. The potting mixture was 2:1 peat:perlite without fertilizer added. The pots were arranged in a complete randomized design and watered equally every alternate day. Harvest occurred after 60 d and tuber yields (number and fresh weight) were recorded.

GA<sub>3</sub> caused significantly more sprouts per minituber ( $4.2 \pm 0.37$ ) than the other treatments, with 100% signal solution ( $2.0 \pm 0.31$ ) and BE ( $1.8 \pm 0.2$ ) giving intermediate values, and water-soaking and cutting similar to the control (Table 8). The average number of tubers per plant was greatest in the GA<sub>3</sub> treatment (3.6); almost double that of other treatments that were not different from the control. Surprisingly, however, the mean fresh weight of tubers (per replicate i.e. pot basis) harvested from minitubers exposed to the 100% signal solution treatment was the greatest (34.97 g); greater than the control fresh weight and three times more than the GA<sub>3</sub> treatment. The size and shape of tubers harvested from the GA<sub>3</sub> treatment were small and more elongated than that of the control and other treatments. Yields from BE treated minitubers were significantly lower compared with controls. The cut halves each yielded almost the same as uncut controls and had similar fresh weight to control (28.41 vs 27.16). Two cut halves of each minituber together would effectively double control yield and bring the mean number of tubers into the GA<sub>3</sub> treatment range. However, cutting into halves posed a problem of infection and decomposition at the cut surfaces.

Thus, although signal solution is not as efficacious as GA<sub>3</sub> in breaking dormancy (as evaluated by the number of sprouts), it however is significantly more efficient than GA<sub>3</sub> in increasing the tuber yield. LCOs therefore appear as the best agents to promote dormancy breaking and yield increases in potato.

**TABLE 8**

**Harvests after 60 d from minitubers that were forced to break dormancy by different methods.**

Treatments	Mean number sprouts at planting $\pm$ SE	Mean number of tubers produced per replicate	Mean fresh weight (g)
GA <sub>3</sub>	4.2 $\pm$ 0.37	3.6*	11.13 d
Cutting into halves (1/2 minituber)	1.2 $\pm$ 0.20	2.0	28.41 b
Bromoethane	1.8 $\pm$ 0.20	2.0	14.01d
100% Signal soln.	2.0 $\pm$ 0.31	1.8	34.97 a
Water	1.2 $\pm$ 0.20	1.0	17.41 c
Control	1.0 $\pm$ 0	2.0	27.16 b

Numbers represented by the same letter are not significantly different at the 0.05 level.

It shall be recognized therefore that agricultural compositions comprising at least one LCO and gibberellic acid (GA<sub>3</sub> and others known in the art) could be advantageously used in accordance with the methods of the present invention to break dormancy and/or quiescence of crop plants.

#### **EXAMPLE 11**

##### **Other LCOs**

Following the methods described above, the LCO most abundantly produced by *R. meliloti* (Nod Rm-V(C<sub>16:2</sub>, S)) was isolated and tested

on alfalfa (*Medicago sativa*) seeds. Briefly, 10 seeds were placed in a disk of filter paper on a petri plate. The filter paper was wetted with 5 ml of the appropriate LCO solution. Data were taken at 12 hour intervals upon the radicle (an embryonic root). The number of seed with an emerged radicle were  
5 counted. Each treatment was repeated four times. The data presented in table 9 indicate a clear acceleration of growth. In this case no standard for HPLC calibration was available, so a relative dilution series was used. In addition, a cluster of peaks specifically induced by the specific flavone of *Rhizobium leguminosarum* (bv *phaseoli* [strain 127K105]) were collected and tested on corn  
10 (*Zea mays*), red clover (*Trifolium repens*, Fabaceae) and pea (*Pisum sativum*, Fabaceae) (Table 10). In each case, a stimulation of seed germination was observed. Of note, *Rhizobium leguminosarum* produces a large number of LCOs. A subset of these LCOs was selected from a range of the HPLC profile where the LCOs from *B. japonicum* and *R. meliloti* did not occur. Taken  
15 together, these results clearly demonstrate that the promoting effects of LCOs on plant growth disclosed herein are observable with LCOs from different bacterial strains involved in bacteria-legume signalling. Consequently, the presented data strongly suggests that LCOs in general should demonstrate the same effects on seed germination, seedling emergence, growth, dormancy  
20 breakage and the like.

**TABLE 9**

**Effect of LCO isolated from *Rhizobium meliloti* (RCR 2011)  
on germination of alfalfa after 24 h of treatment**

Treatment	Percent Germination
Control	16.7b
10 <sup>-1</sup> dilution	26.6ab
10 <sup>-2</sup> dilution	26.6ab
10 <sup>-3</sup> dilution	36.6a
LSD ( $p < 0.05$ )	19.2

In column numbers followed by same letter do not differ significantly by an ANOVA protected LSD test at  $p < 0.05$

**TABLE 10**

**Effect of LCOs of *Rhizobium leguminosarum* bv *phaseoli* (strain 127K105) on seed germination (%) of corn (after 48h), red clover (after 12h) and pea (after 48h) at 25°C**

Treatment	Corn	Red Clover	Pea
Control	20a	43.3bc	26.6b
10 <sup>-1</sup> dilution	26.6a	26.6c	26.6b
10 <sup>-2</sup> dilution	60.0b	63.3ab	20.0b
10 <sup>-3</sup> dilution	20.0a	66.6a	73.3a
LSD ( $p < 0.05$ )	19.9	23.3	29.7

In column numbers followed by same letter do not differ significantly by an ANOVA protected LSD test at  $p < 0.05$

**EXAMPLE 12****Germination versus emergence**

Seeds of corn (cv Pioneer 3921) were surface sterilized in 2% sodium hypochlorite solution for 2 minutes and placed in 9 cm diameter Petri plates containing a sheet of filter paper soaked in 10 ml of the required test solution (LCO  $10^{-5}$  -  $10^{-13}$ ). Water served as the control. Observations on germination, length of root primodia and shoot were taken after 72 h of incubation at 25°C. The data was analyzed for significance by an ANOVA protected LSD test using SAS system Version 6.1 (SAS Inc., Cary, NC, USA).

**TABLE 11**

**Effect of lipo chitoooligosaccharide [Bj Nod-V (C<sub>18:1</sub> MeFuc)] on germination of corn (*Zea mays* L.) after 72 h of treatment**

Treatment	Percent germination	Length of root primodia (mm)	Length of shoot primodia (mm)
Control	46.6 a	32.3 a	4.6 a
LCO $10^{-5}$ M	80 bc	53.0 ab	12.3 ab
LCO $10^{-7}$ M	73.3 b	57.6 bc	15.0 ab
LCO $10^{-9}$ M	73.3 b	48.0 ab	9.6 a
LCO $10^{-11}$ M	100 c	78.6 c	21.0 b
LCO $10^{-13}$ M	80 bc	43.0 bc	8.3 a
LSD (p<0.05)	22.6	24.3	11.0

In column numbers followed by same letter do not differ significantly by an ANOVA protected LSD test at  $p < 0.05$ .

Table 11 shows that incubation of corn seeds with LCO solution significantly improved the germination of corn and increased the length of both shoot and roots.



**EXAMPLE 13****Seedling emergence-promoting effects of LCOs  
under field conditions**

5       Seeds of corn, cotton, beet, and soybean which showed  
promising results under laboratory conditions were tested for seedling  
emergence under field condition. Seeds were surface sterilized with 2% sodium  
hypochlorite and soaked in different concentrations ( $10^{-5}$ ,  $10^{-7}$ ,  $10^{-9}$ M) of LCO  
solution for 12 h. Water served as the control. The study was conducted at the  
experimental field of the Macdonald campus of McGill University, Ste-Anne-de-  
10   Belleveue. Quebec, Canada. The field was ploughed to a fine tilth. seeds were  
hand planted in 1 m rows at 2.5 to 3 cm deep with three replications per  
treatment. The percent seedling emergence was observed at six days after  
planting during which time at least 50% of the seeds emerged in the treatments.  
The data was analyzed for significance by an ANOVA protected LSD test using  
15   SAS system Version 6.1 (SAS Inc., Cary, NC, USA).

**TABLE 12**

**Effect of lipo chitooligosaccharide [Bj Nod-V (C<sub>18:1</sub> MeFuc)] on seedling emergence under field condition**

Treatment	Corn	Cotton	Beet	Soybean
Control	41.6 a	6.6 a	26.6 a	16.6 a
LCO 10 <sup>-5</sup> M	80.0 b	16.6 a	28.3 a	26.6 ab
LCO 10 <sup>-7</sup> M	60.0 b	60.0 b	46.6 c	33.3 b
LCO 10 <sup>-9</sup> M	53.3 b	23.3 a	38.3 ab	63.3 c
LSD (P< 0.05)	35.7	28.0	16.3	16.6

In column numbers followed by same letter do not differ significantly by an ANOVA protected LSD test at p < 0.05

Table 12 shows that LCO [Bj Nod-V (C<sub>18:1</sub> MeFuc)] treatment enhanced the seedling emergence under field conditions of all the crop species studied. The best effect was observed in cotton where LCO at 10<sup>-7</sup>M improved the emergence by more than 9 times as compared to the control. The effective concentration of LCO varied with the species.

Table 12 also validates the laboratory results presented herein by demonstrating that the stimulatory effects of LCOs are operating on four different crops under field conditions.

Thus the present invention provides agricultural compositions and methods by which LCO could be used to enhance the germination, seedling emergence, root growth and improve early growth of crops under laboratory or field conditions.

## **CONCLUSION**

The present invention therefore provides evidence that, among other things: (1) lipo chitooligosaccharide (LCO) treatment enhances the seedling emergence of higher plant seeds (egs. *Z. mays*, *L. sativa*, *B. vulgaris*, *P. vulgaris*, *G. max* *C. sativus*, *B. napus* and *M. sativa*); (2) lipo

chitooligosaccharide breaks the dormancy of potato (*Solanum tuberosum*)  
minitubers and increases their yield; (3) lipo chitooligosaccharide improves  
emergence and early growth, including root growth, of *Z. mays* giving a  
competitive advantage over non treated ones; (4) lipo chitooligosaccharide  
5 enhances the translocation of stored seed reserve; and (5) lipo  
chitooligosaccharide enhances seed germination.

Although the present invention has been described  
hereinabove by way of preferred embodiments thereof, it can be modified,  
without departing from the spirit and nature of the subject invention as defined  
10 in the appended claims.

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**WHAT IS CLAIMED IS:**

1. An agricultural composition for enhancing plant crop seed germination and/or seedling emergence and/or growth of a plant crop comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier.
2. The composition of claim 1, wherein said plant crop is a non-legume.
3. The composition of claim 2, wherein said plant crop is selected from the group consisting of Poaceae, Cucurbitaceae, Malvaceae, Asteraceae, Chenopodiaceae, Solonaceae and Brassicaceae.
4. The composition of claim 3, wherein said plant crop is selected from the group consisting of corn, cotton, cucumber, cantaloupe, lettuce, beet, canola and potato.
5. The composition of one of claims 1 to 4, wherein said LCO is obtainable from a rhizobia selected from the group consisting of *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.
6. The composition of claim 5, wherein said LCO is present in said composition at a concentration of between about  $10^{-5}$  M to about  $10^{-14}$  M.
7. The composition of claim 5, wherein said LCO is present in said composition at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.

8. The composition of claim 5, wherein said LCO is present in said composition at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

5 9. The composition of one of claims 1 to 8, wherein said composition is effective in enhancing seed germination and/or seedling emergence and/or growth of a plant crop under field conditions.

10 10. The composition of claim 1, wherein said plant is a member of the Fabaceae family.

11. The composition of claim 10, wherein said plant is selected from the group consisting of soybean, bean, alfalfa and clover.

15 12. The composition of claim 10 or 11, wherein said LCO is obtainable from a rhizobia selected from the group consisting of *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.

20 13. The composition of claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-5}$  M to about  $10^{-14}$  M.

25 14. The composition of claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.

15. The composition of claim 12, wherein said LCO is present in said composition at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

16. The composition of one of claims 10 to 15, wherein said composition is effective in enhancing seed germination and/or seedling emergence and/or growth of a plant crop under field conditions.

5 17. A composition for breaking the dormancy and/or quiescence of a plant comprising a growth-promoting amount of at least one lipo chitooligosaccharide (LCO) together with an agriculturally suitable carrier.

10 18. The composition of claim 17, wherein said plant is a member of the family of Solonaceae.

19. The composition of claim 18, wherein said plant is a potato.

15 20. The composition of claim 19, wherein said growth-promoting activity of said composition enables an increase in yield.

20 21. The composition of claim 19, further comprising gibberellic acid.

22. A method for enhancing seed germination and/or seedling emergence and/or growth of a plant, comprising a treatment in the vicinity of one of a seed, root or plant with a composition comprising an agriculturally effective amount of a lipo chitooligosaccharide (LCO) in admixture with an agriculturally suitable carrier medium, wherein said effective amount enhances seed germination and/or seedling emergence and/or growth of said plant in comparison to an untreated plant.

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23. The method of claim 22, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-5}$  M to about  $10^{-14}$  M.

5                   24. The method of claim 23, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-6}$  M to about  $10^{-12}$  M.

10                   25. The method of claim 24, wherein said composition comprises at least one LCO at a concentration of between about  $10^{-7}$  M to about  $10^{-10}$  M.

15                   26. A method for enhancing seed germination and/or seedling emergence and/or growth of a plant crop comprising incubating a rhizobial strain which expresses a lipo chitooligosaccharide (LCO) in the vicinity of one of a seed and/or root of said plant such that said LCO enhances seed germination and/or seedling emergence and/or growth of said plant crop.

20                   27. The method of claim 26, wherein said plant crop is a non-legume.

25                   28. The composition of claim 27, wherein said plant crop is selected from the group consisting of Poaceae, Cucurbitaceae, Malvaceae, Asteraceae, Chenopodiaceae, Solonaceae and Brassicaceae.

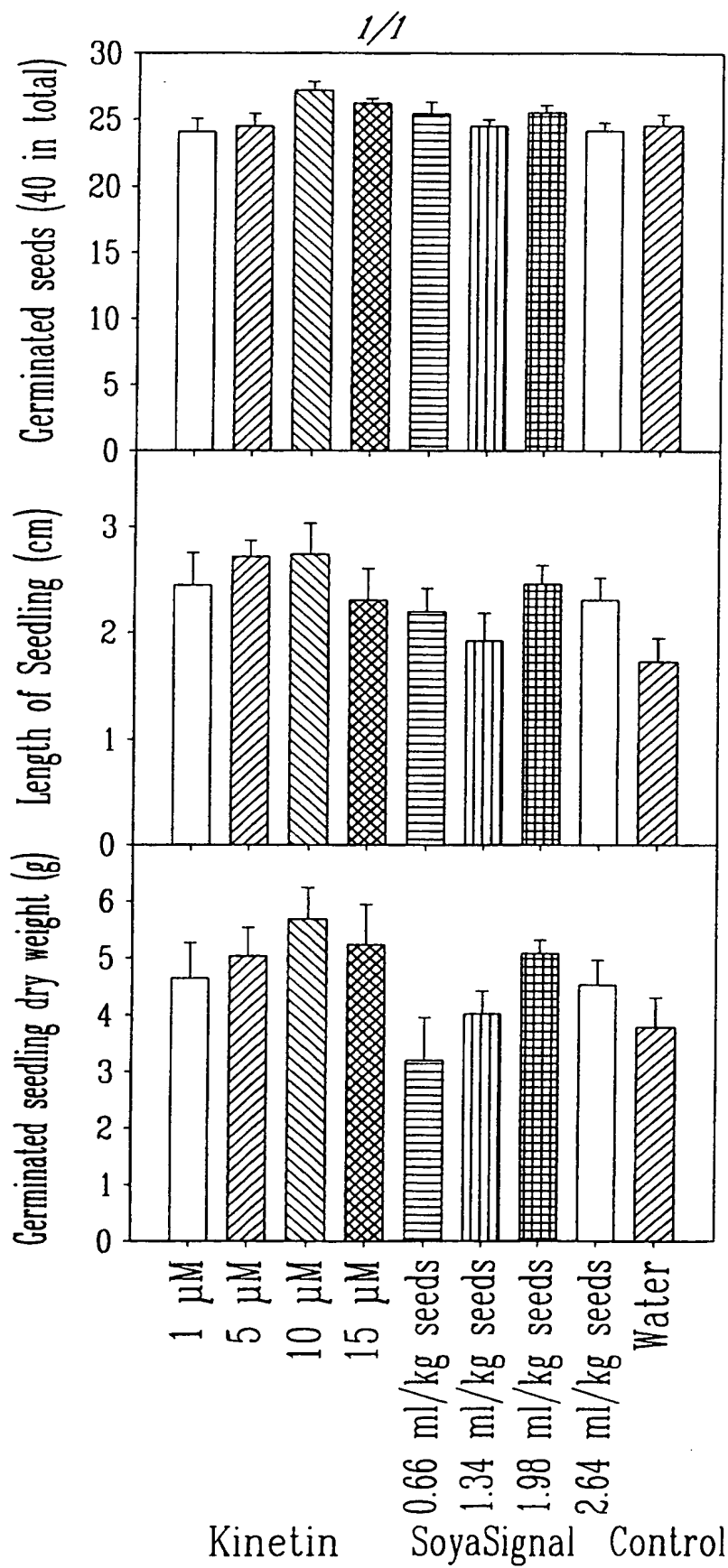
29. The composition of claim 28, wherein said plant crop is selected from the group consisting of corn, cotton, cucumber, cantaloupe, lettuce, beet, canola and potato.



30. The method of one of claims 26 to 29, wherein said rhizobia is selected from *Bradyrhizobium japonicum*, *Rhizobium meliloti* and *Rhizobium leguminosarum*.

5                   31. The method of one of claims 26 to 30, wherein said LCO enhances seed germination and/or seedling emergence and/or growth of said plant under field conditions.

10                   32. The method of claim 26, wherein said plant crop is a legume in the Fabaceae family and wherein said LCO enhances seed germination and/or seedling emergence and/or growth of said legume under field conditions.



# INTERNATIONAL RCH REPORT

International Application No

PC1/CA 99/00666

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 A01N63/00 A01N43/16

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 A01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CHEMICAL ABSTRACTS, vol. 123, no. 13, 25 September 1995 (1995-09-25) Columbus, Ohio, US; abstract no. 165208, ROEHRIG, HORST ET AL: "Growth of tobacco protoplasts stimulated by synthetic lipo-chitooligosaccharides." XP000000021 abstract & SCIENCE (WASHINGTON, D. C.) (1995), 269(5225), 841-3 , ---	1-32
X	WO 91 15496 A (CNRS) 17 October 1991 (1991-10-17) * see the whole document* & US 5 549 718 A cited in the application --- -/--	1,5-17, 22-26,32

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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International Application No

PCT/CA 99/00666

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